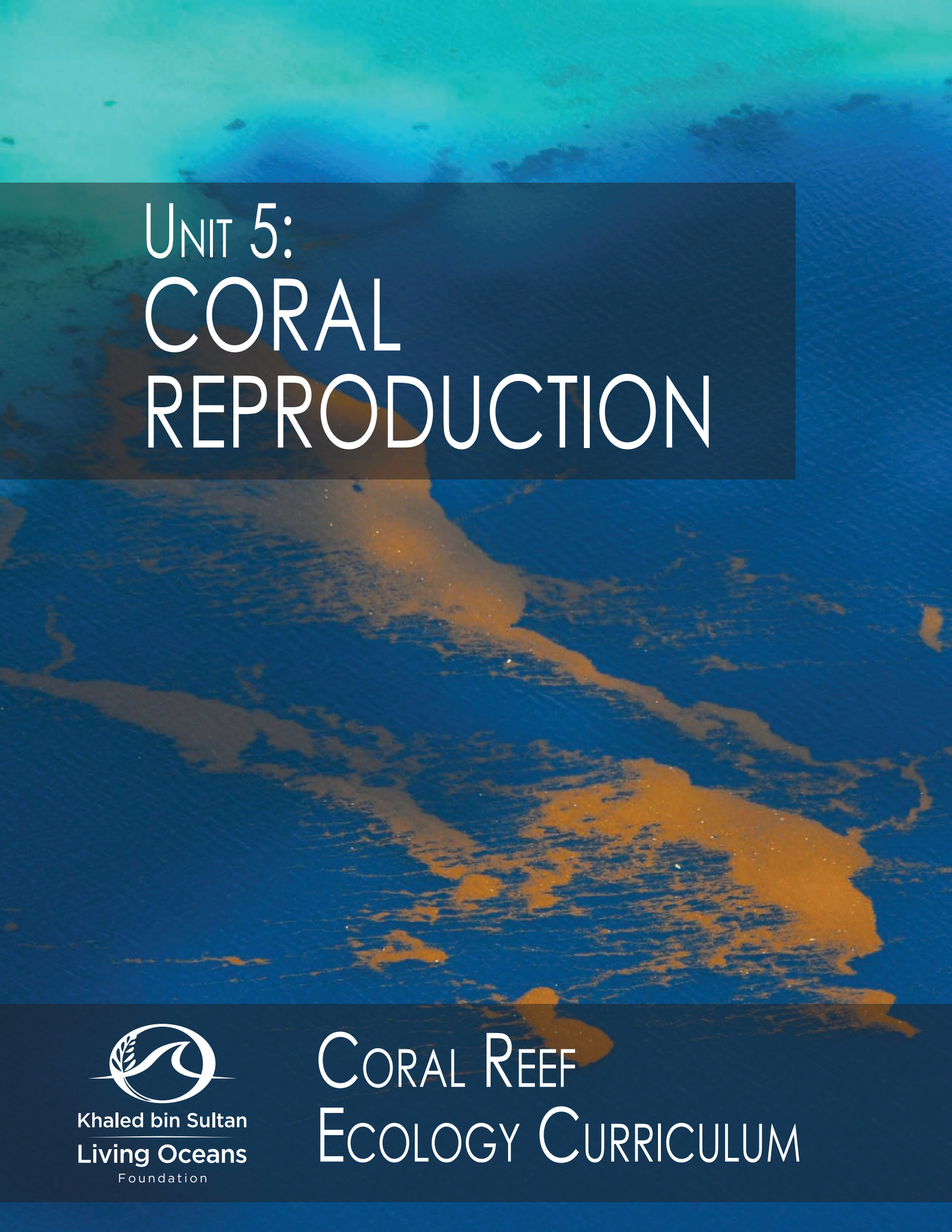

Unit 5: Coral Reproduction

Khaled bin Sultan Living Oceans Foundation

Coral Reef Ecology Curriculum

Khaled bin Sultan
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Foundation

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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Cover Photo: ©Michele Westmorland/iLCP

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STANDARDS

- **CCSS**: RST.9-10.1, 2, 3, 4, 5, 6, 7, 8, 9, 10; RST.11-12.1, 2, 3, 4, 6, 10; SL.9-10.1, 6; SL.11-12.1, 6
- **NGSS**: HS-LS2-8
- **OLP**: 5.C.44, 5.C.47, 5.C.48, 5.C.50, 5.C.53, 5.C.54, 5.C.55, 5.C.56

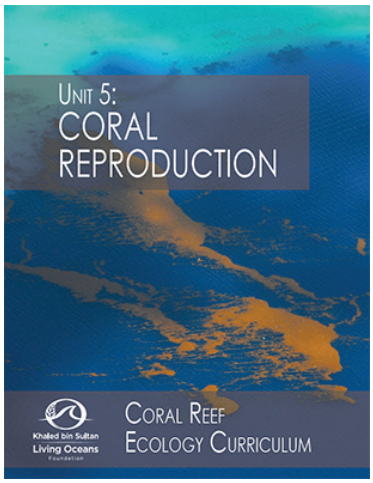
ONLINE CONTENTS

- Coral Reproduction Quiz
- *Corals: The Birds and the Bees* Video How do coral colonies ensure their own survival generation after generation? Corals reproduce sexually (mass spawning and brooding) and asexually (budding and fragmentation).

CORAL REPRODUCTION

This lesson is a part of the *Coral Reproduction* unit, which explains different strategies that corals use to reproduce. Below is a summary of what is included in the entire unit.

UNIT CONTENTS



A. Background Information
   - Reproduction
   - Sexual Reproduction
   - Asexual Reproduction

B. Lessons

Watch it! Birds and the Bees
- A worksheet to accompany the *Birds and the Bees* video

Safety in Numbers
- A game of tag adapted to learn the advantages of mass spawning

Comic Clones
- An activity to make a comic strip describing a form of asexual reproduction

Read it! Rolling Stones
- A worksheet to accompany the *Rolling Stones* field blog

BACKGROUND INFORMATION

Reproduction is the process of creating offspring. Organisms must reproduce in order for their species to survive. How do corals reproduce? Remember that corals are **sessile** so they have to be creative when it comes to reproduction. In this unit, we will learn about different strategies that coral use to reproduce.

Corals reproduce by one of two methods:

1. Sexual reproduction
2. Asexual reproduction

A) SEXUAL REPRODUCTION

Let's begin with **sexual reproduction,** the production of a new organism from two others of the opposite sex. This requires the production of sperm and eggs, which are often referred to as gametes. **Gametes** are mature sexual reproductive cells. The majority of coral species are **hermaphroditic,** meaning that they produce both sperm and eggs. The rest consist of separate sexes (male or female) meaning that they produce either eggs or sperm. When a sperm and egg combine to form a new organism it is called **fertilization**.

The majority of corals are considered hermaphroditic broadcast spawners, a type of external fertilization. **Broadcast spawners**, sometimes referred to as **mass spawners** or **synchronous spawners**, release both sperm and eggs into the water at the same time (figure 5-1). Some corals release **buoyant** egg and sperm bundles. These do not self fertilize, but instead, they float to the water's surface where they break apart, releasing gametes, which then combine with those from other corals, completing the process of fertilization. Other corals fertilize the eggs internally in the **gastrovascular cavity** (see *Unit 3: Coral Anatomy*), and allow them to grow into **planulae** (see *Unit 3: Coral Anatomy*). These corals are called **brooders**.

Both of these are different reproductive strategies that have various outcomes. Can you think of the benefits and disadvantages of each of these strategies?

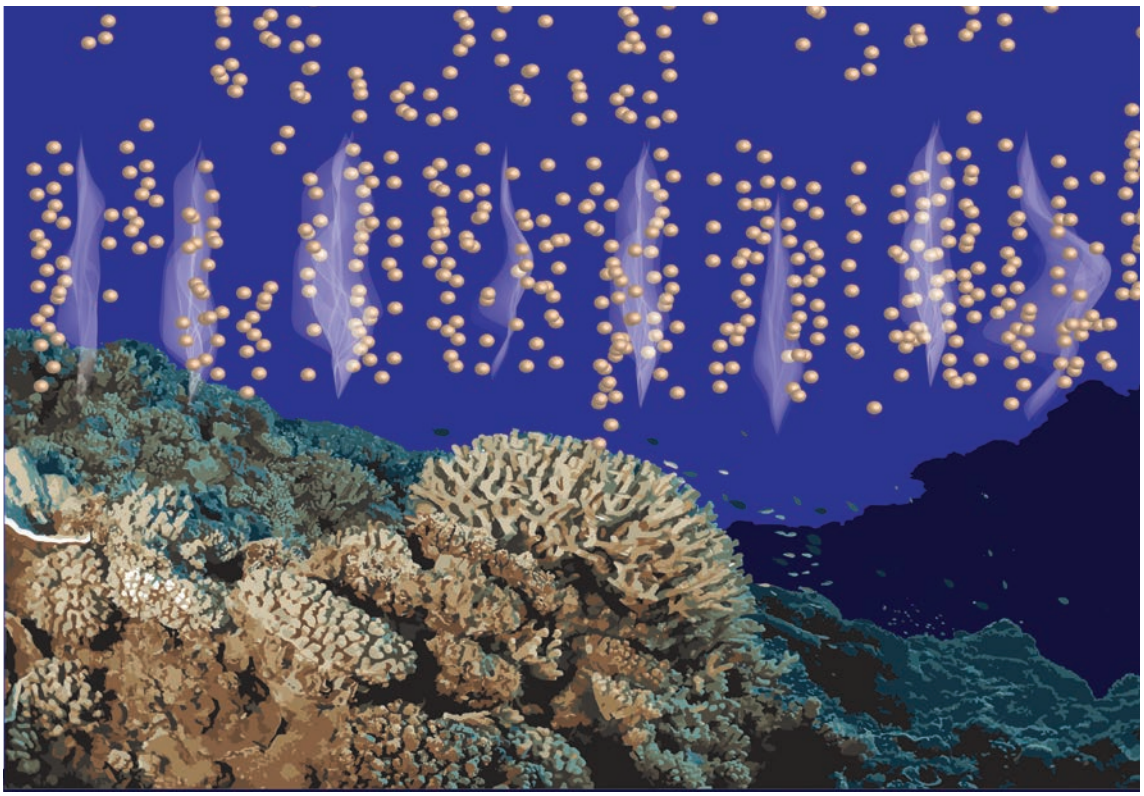


FIGURE 5-1. Mass spawning event where the round objects are eggs and the white clouds are sperm.

Benefit to Spawners	Benefit to Brooders
More sperm and eggs released; safety in numbers	Fewer but better developed planulae
Carried in currents over greater distances; greater genetic diversity	Can settle immediately; less chance of getting eaten
Requires less energy	Can release planulae at any time because it is already in its planktonic stage
Disadvantage to Spawners	**Disadvantage to Brooders**
Longer distance = less chance of survival	Less genetic diversity
Have to get the synchronization correct for gametes to be able to reproduce	Requires more energy

Some corals can actually use a combination of brooding and spawning in order to benefit from each reproductive strategy and ensure the survival of their species.

A mass spawning occurs when many different coral species synchronize the release of their eggs and sperm. Mass spawnings have been observed on coral reefs throughout the world. Usually the event occurs once a year; however, two spawnings have been documented. Additionally, in some areas, minor spawning events occur throughout the year. Generally, spawning events take place after a full moon during certain times of the year, dependent on location.

Here are a few examples:

- Great Barrier Reef, Australia; occurs in October or November and sometimes December, 4-5 days after the full moon (GBRMPA 2011)
- Western Australia; occurs in March or April, 4-14 days after the full moon (Babcock *et al.* 1994)
- Florida Keys; occurs in August or September, 3-5 days after the full moon (Szmant 1986)
- Flower Garden Banks, Gulf of Mexico; occurs in August, 7-10 days after the full moon (National Ocean Service 2014)

Other non-coral **invertebrates** have been observed releasing their gametes during the mass spawning as well, including sea stars, sea urchins, sea cucumbers, sponges, marine worms, and molluscs. Again, this reproductive behavior is beneficial by allowing a large amount of gametes to be present; therefore, the likelihood of an individual being eaten is decreased. This is sometimes referred to as **safety in numbers**. Even though there is a feeding frenzy by fish and invertebrates (figure 5-2), there are many gametes present and many will survive.

FIGURE 5-2. Brittle star feeding on coral's gametes

In areas like the Great Barrier Reef, the spawn is so large that a pink slick of unfertilized eggs and **embryos** (fertilized eggs) can be seen on the surface of the ocean (see unit cover).

Some corals are **asynchronous spawners** meaning that they can spawn during the mass spawn, but they are more likely to spawn before or after it. Different species spawn at different times.

There are certain environmental cues that tell corals when to spawn. It is unclear exactly which cues affect spawning events, though it is believed that corals respond to multiple environmental cues. What environmental cues do you think could affect spawning?

Here are some potential environmental cues:

- Sea temperature
- Salinity
- Storms and weather conditions
- Currents
- Latitudinal variation
- Day length
- Tidal cycle
- Lunar cycle
- Chemical signaling
- Wind patterns
- Anthropogenic effects

As corals become more threatened by **anthropogenic,** or human produced effects, it is likely that successful coral reproduction will also be at risk (see *Unit 19:Threats*).

B) ASEXUAL REPRODUCTION

The second way that corals can reproduce is via **asexual reproduction**. Asexual reproduction is a means of reproduction where a new organism arises from a single organism. This new organism will only have the genes of the parent organism and it is an identical clone of the parent. Corals use several different methods of asexual reproduction.

1. **Fragmentation**: when a piece of coral intentionally or unintentionally (storms, human disturbance, etc.) is broken off from the parent coral. It can grow, developing into a mature coral and starting new colonies. This method is often used by people to restore coral reefs (figure 5-3). A fragment can be broken off, grown until they are healthy and mature enough, and then transplanted on to a coral reef.

FIGURE 5-3. A coral nursery in Vava'u, Tonga

2. **Budding** (figure 5-4): This category of asexual reproduction is found in all colonial corals. Budding occurs when a portion of the parent polyp pinches off to form a new individual. There are two ways in which this occurs:
   - **Intra-tentacular**: Buds form from the parent polyp's **oral disks**, producing same-sized polyps within the ring of **tentacles** (figure 5-5a).
   - **Extra-tentacular**: Buds forms outside the parent polyp's ring of tentacles, producing a smaller polyp (figure 5-5b).

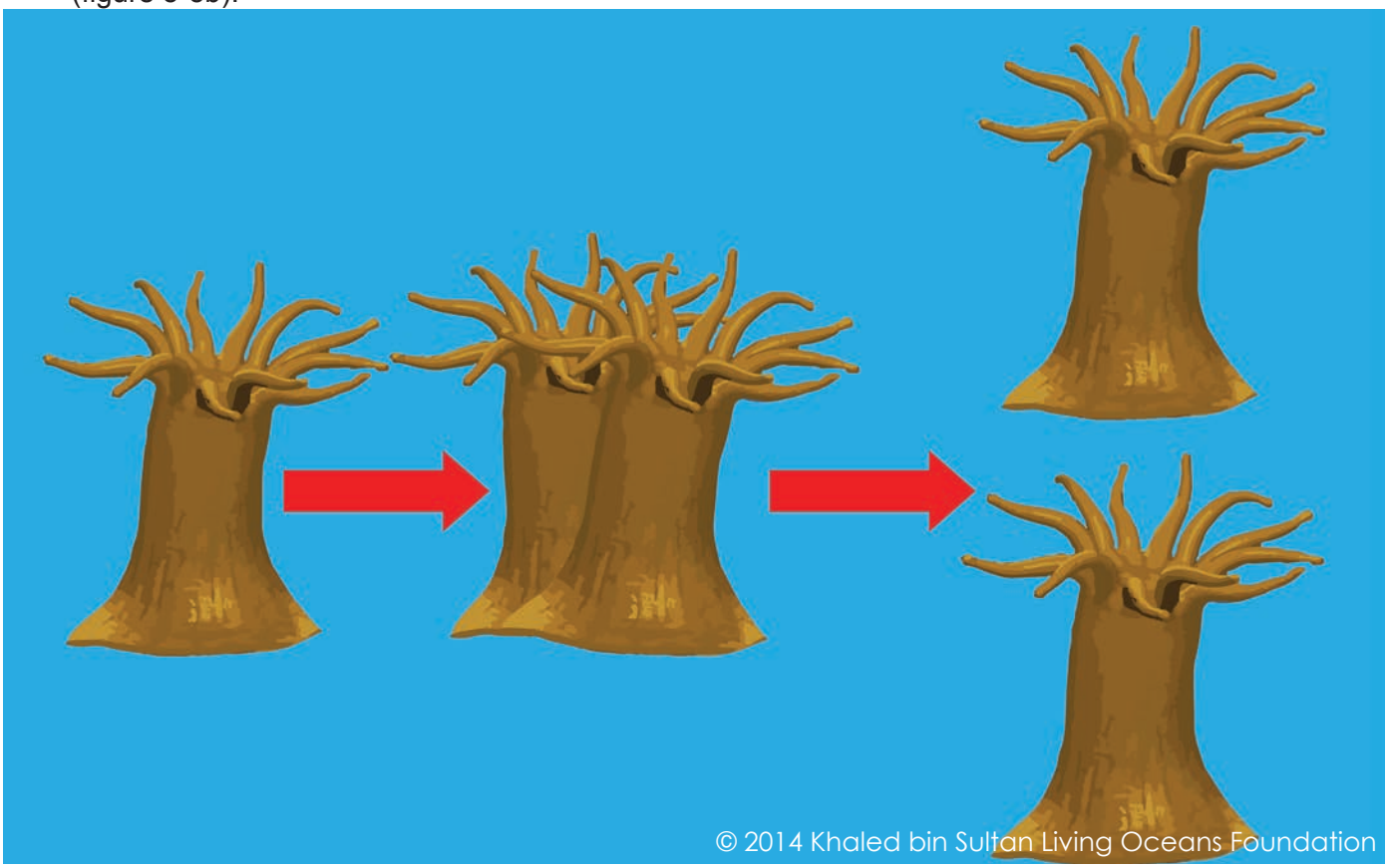


FIGURE 5-4. Coral budding

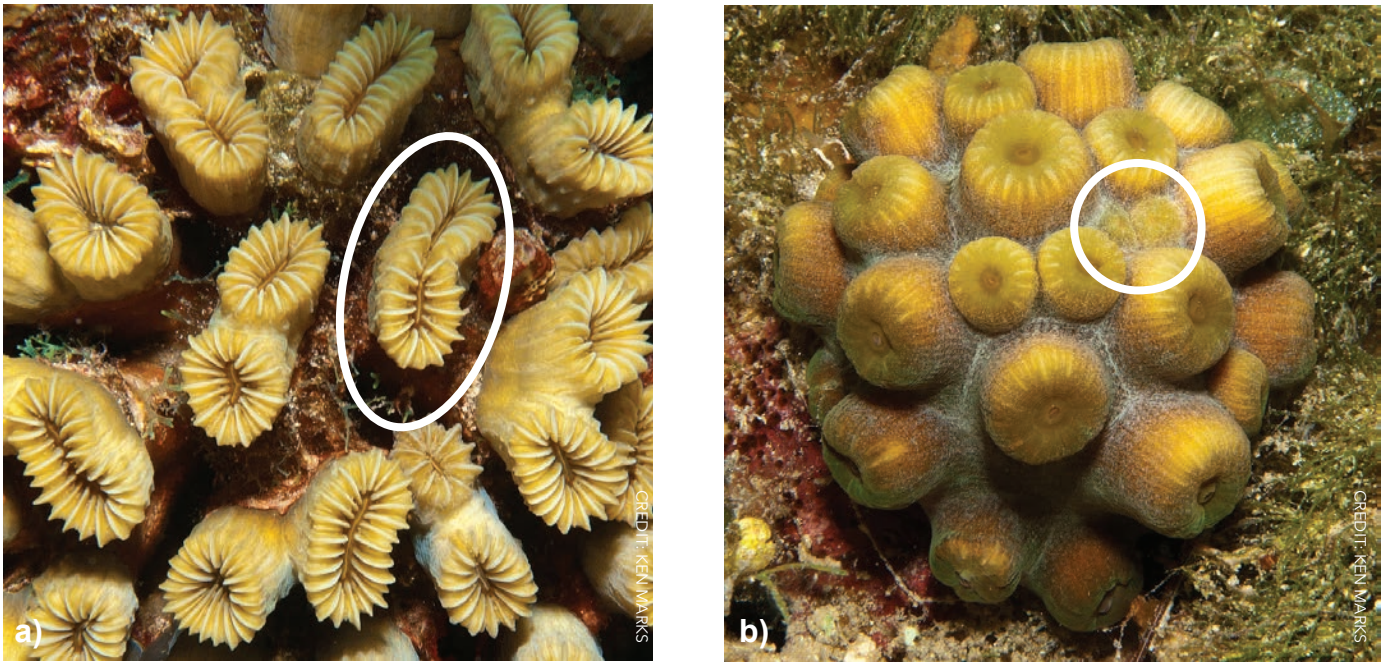


FIGURE 5-5. a) Intra-tentacular budding; b) Extra-tentacular budding

3. **Fission**: During early developmental stages, some coral colonies have the ability to split into two or more colonies. This sometimes occurs with corals from the Family Fungiidae, the mushroom corals (figure 5-6). They are solitary corals that can decalcify, or break up, their skeletons, creating two pieces and then growing their other half back. Other similar types of reproduction occur in Fungiids. They can decalcify part of the skeleton forming acanthocauli (juvenile polyps formed asexually). These **polyps** grow on top of their dead parents and eventually break off into individual polyps.

FIGURE 5-6. Mushroom coral undergoing fission

4. **Bailout** (figure 5-7): When a single polyp abandons its colony and settles on the substrate to create a new colony. Sometimes this is due to a stressful event such as coral bleaching (Sammarco 1982).

FIGURE 5-7. Bailout of a staghorn coral polyp

ATTRIBUTIONS

Figure 5-2. By Haplochromis [Public domain], 16 February 2007 via Wikimedia Commons. *http://commons.wikimedia.org/wiki/File%3AStony_coral_spawning.jpg*.

Figure 5-7. For use of staghorn coral vector. By Tracey Saxby, Integration and Application Network, University of Maryland Center for Environmental Science (*ian.umces.edu/imagelibrary/*).

CITATIONS

Babcock, R. C., Wills, B. L., & Simpson, C. J. (1994). Mass spawning of corals on a high latitude coral reef. *Coral Reefs* 13: 161-169.

Great Barrier Reef Marine Park Authority (GBRMPA). (2011). Coral Reproduction. Retrieved May 16, 2014 from *http://www.gbrmpa.gov.au/about-the-reef/corals/coral-reproduction*.

National Ocean Service. (10 February, 2014). Coral Spawning. Retrieved May 16, 2014 from *http://flowergarden.noaa.gov/education/coralspawning.html*.

Sammarco, P. W. (1982). Polyp bail-out: An escape response to environmental stress and the new means of reproduction in corals. *Marine Ecology Progress Series* 10: 57-65.

Szmant, A. M. (1986). Reproductive ecology of Caribbean reef corals. *Coral Reefs* 5: 43-54.

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.