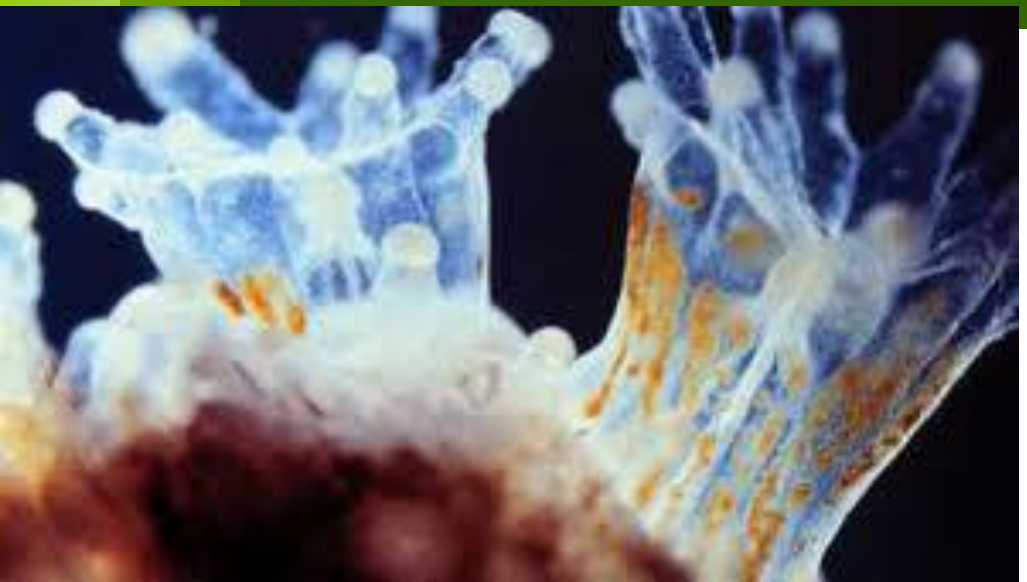
# Zooxantella (Algal Symbionts)

- Tropical Marine Biology Bootani-



by

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# The outline

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- Zooxanthellae-Coral Reef
- Zooxanthellae-Coral Symbiosis
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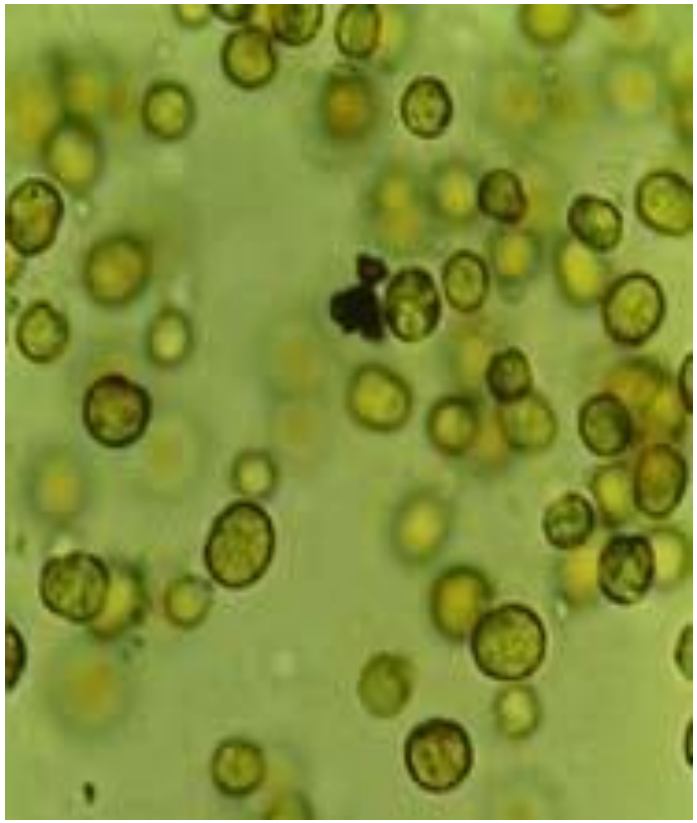
- The adaptation

# What is zooxanthellae?

- “Zooxanthellae” is a plural noun (singular: zooxanthella) derived from the Greek words zoo (animal), xanthos (yellow), and ella (diminutive): “yellow animal cells.
- Zooxanthellae is the name given to a wide array of different algae of the genus *Symbiodinium.*
- These organisms are part of a group of dinoflagellates that are most often found as plankton.
- found in mutualistic symbiosis with a variety of invertebrate and protist hosts.

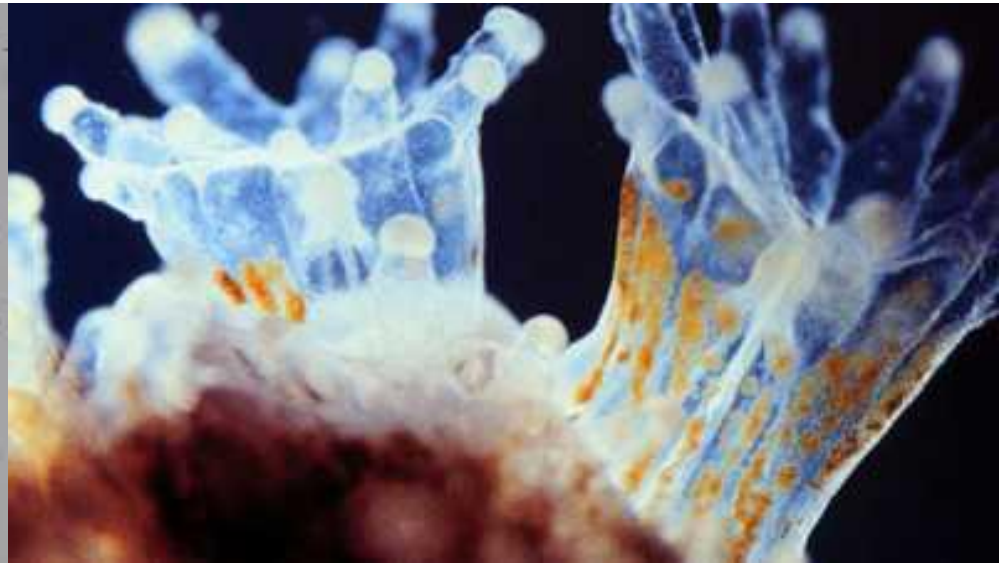


# The characteristics

- Zooxanthellae are yellow-brown single-celled plants that live in the tissues of animals (intracellular endosymbiont)
- Zooxanthellae are unicellular organisms with a spherical shape
- They have two flagella, although these are lost if the organism is acquired by a host. This is called the coccoid state.
- Zooxanthellae are mixotrophic organisms.
  - mainly photosynthetic organisms (photoautotrophic)
  - some species can also obtain food by ingesting other organisms.

- Zooxanthellae is very small that they can only seen only by electron microscope

**Zooxanthellae inside the cilliates**



**Zooxanthellae inside the polyp of coral**

- Like most plant, phytoplankton are able to convert sun's energy into food through photosynthesys
- Photosynthates from dinoflagellate zooxanthellae (in the genus Symbiodinium) have been shown to account for 50–95% of the coral's energy budgets.

- Sources of Photosynthesis :
  - Sunlight
  - Carbon Sources

  Product of Photosynthesis :
  - Oxygen
  - Glycerol
  - Glucose
  - Alanin, Aspartate and Glutamate
  - Fatty acid
  - Lipids

# The habitat

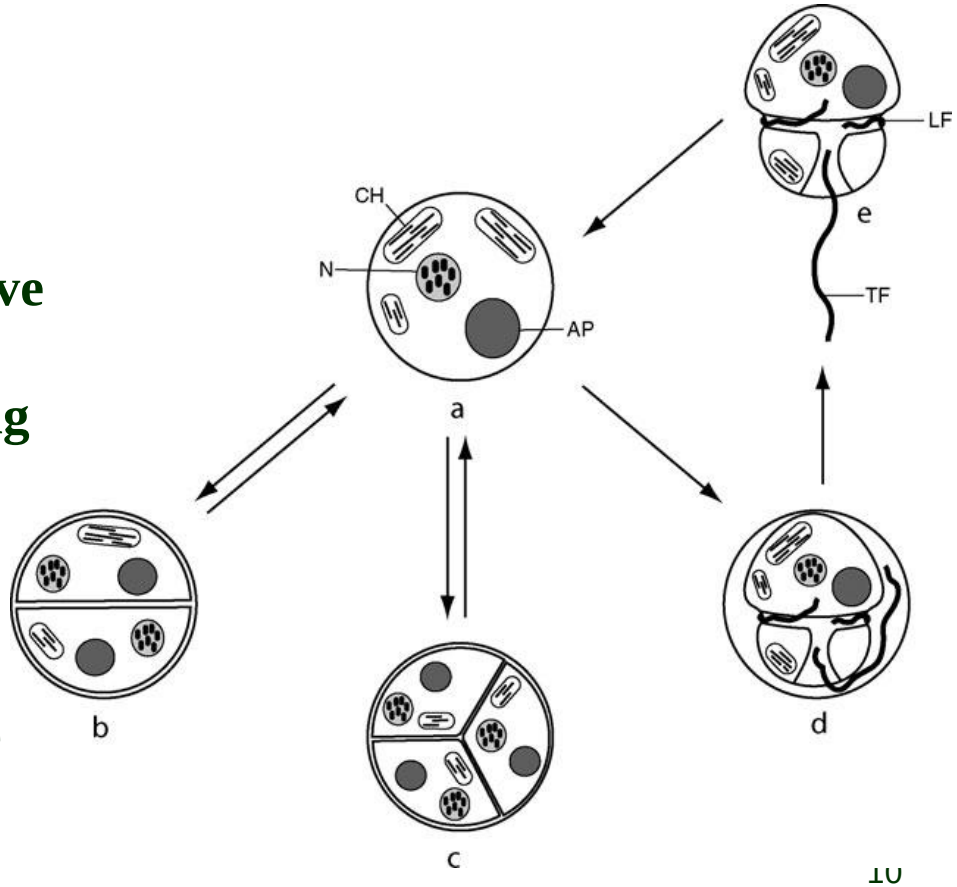
- Inside the endoderm of host
  - Zooxanthellae can inhabit the host
  - Zooxanthellae typically spend their entire life on the organism to which they are attached.
  - Due to need for light, they only live in ocean waters <100 m
- "Free" zooxanthellae are rarely found in plankton samples
  - May become benthic, sessile
  - May go into dormant stage

# The host

- Cnidarian species reported to contain Symbiodinium include many representatives from the class Anthozoa (including anemones, scleractinian corals, black corals,, blue corals, and sea fans)
- the classes Scyphozoa (including coronate jellyfish)
- Hydrozoa (including milleporine fire corals).
- Symbiodinium has also been identified from gastropod and bivalve mollusks (including tridacnid [giant] clams, and conch), large miliolid foraminifera (in the subfamily Soritinae), sponges, and a giant heterotrich ciliate

# The life cycle

- The life cycle of Symbiodinium alternates between a vegetative cyst and a motile zoospore by  division is the most common form of reproduction.




**Life cycle of Symbiodinium (a) vegetative cyst, (b) dividing vegetative cyst producing two daughter cells, (c) dividing vegetative cyst producing three daughter cells, (d) developing zoospore, and (e) zoospore. CH: chloroplast; N: nucleus; AP: accumulation product; LF: longitudinal flagella; TF: transverse flagella.**

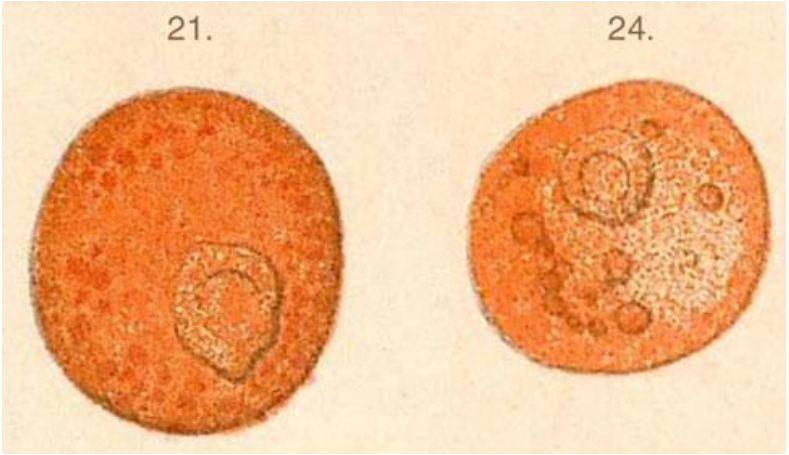
# Transmission of zooxanthellae

- Maternal transmission (vertical) : a direct transmission from the parental colony to the eggs
- Environmental transmission (horisontal) :a larval or post-larval uptake from the environment.
- Corals that produce zooxanthellate oocytes (i.e. vertical or maternal transmission) are expected to exhibit a lower symbiont diversity than corals that produce azooxanthellate oocytes (horizontal transmission), since many more opportunities for the acquisition of new zooxanthella strains are available when corals have to be reinfected every generation. Such corals acquire zooxanthellae from the environment as larval or post-larval stages.

# Taxonomy of zooxanthellae

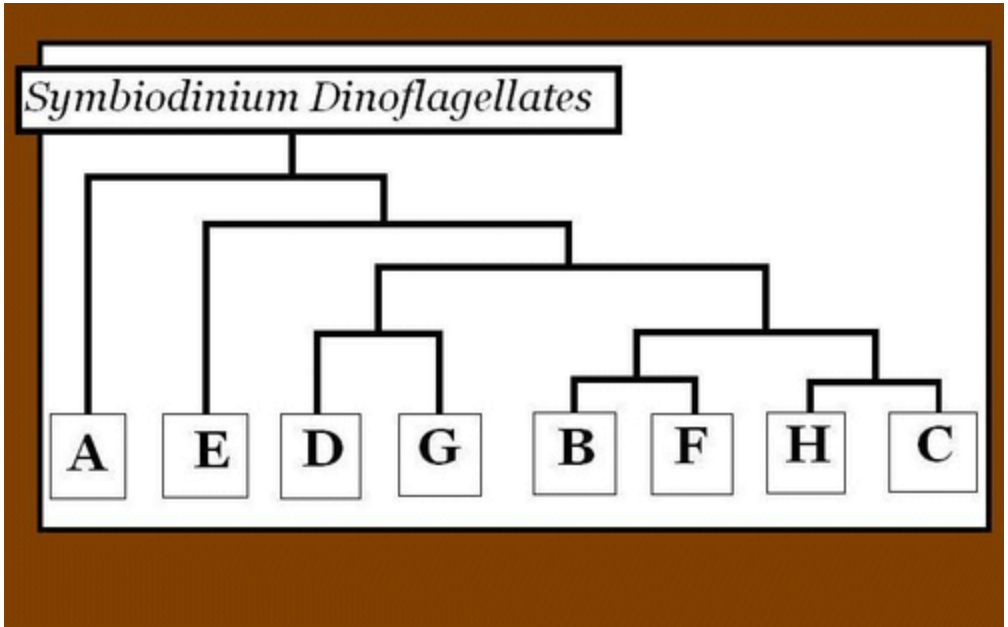
- Taxonomic studies of these algae have been hindered by their problematic
  - a paucity of informative morphology, especially in the vegetative (symbiotic) state
  - the possible complications of host-associated phenotypic plasticity, restricting definitive studies to those zooxanthellae that can be cultured in vitro
  - the absence of sexual reproduction, a lack that precludes genetic investigations

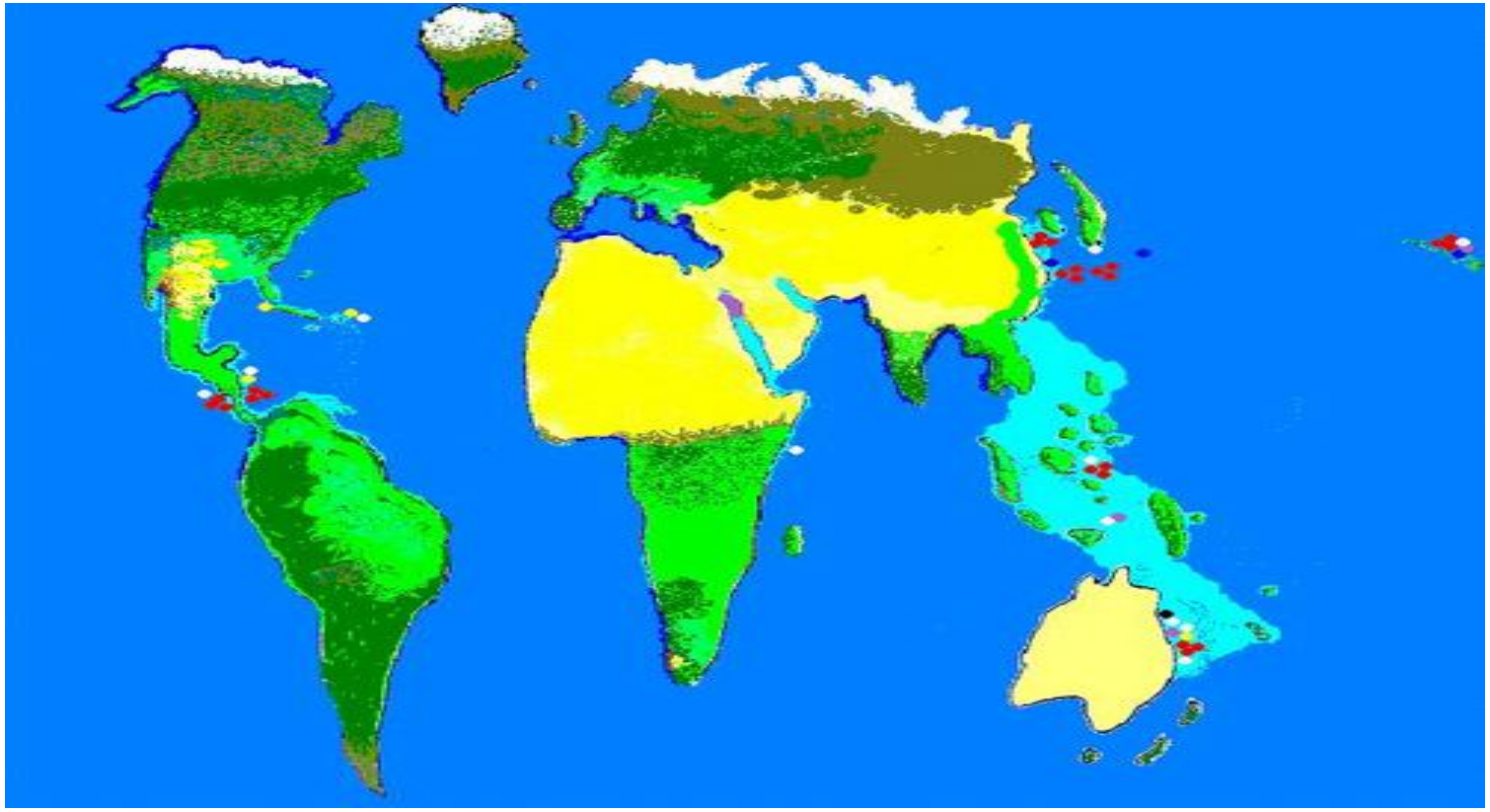
- The first dinoflagellate zooxanthellae were cultured in the 1950s, and in 1962 Hugo Freudenthal introduced a new genus and species *Symbiodinium microadriaticum*,
- from the Greek words means symbion ("living together") and dinos ("whirling")
- It isolated from the jellyfish Cassiopeia xamachana (Freudenthal, 1962).
- It was generally assumed that all symbiotic dinoflagellates belonged to a single pandemic species S. microadriaticum,




**Zooxanthellae, drawings of "zooxanthellae" reproduced from Brandt (1883). Shown are the Gelbe Zellen ("yellow cells") isolated from the scleractinian coral Cladocora caespitosa ("21") and the upside-down jellyfish Cassiopeia borbonica ("24"). Both are Symbiodinium based on their appearance and host origin.**

- In fact, there are currently eight genera in four or five orders of dinoflagellate that are recognized as endosymbiotic zooxanthellae in marine invertebrates and protists
- The dinoflagellate genus Symbiodinium is extraordinarily diverse, and consists of at least eight major clades





**Known locations of zooxanthellae clades. Purple = Clade A; Yellow = Clade B; White = Clade C; Red = Clade D; Dark Blue =Clade F and Black = Clade G. Not surprisingly, identified clade locations are usually near research stations.**

- **Clade "A"**
  - Clade A zooxanthellae are generally considered relatively hardy, and are found in scleractinian corals, octocorals, hydrocorals, clams, anemones and zoanthids. Most hosts of Clade A zooxanthellae are found in the Caribbean, with sporadic reports of occurrences in Australias Great Barrier Reef, the Red Sea and the western Pacific (Korea). Ex : *Symbiodinium microadriaticum*.

- **Clade "B"**
  - As with Clade A zooxanthellae, those of Clade B are relatively resistant to bleaching episodes. Current information suggests this clade is most common in Caribbean octocorals (sea fans, sea whips, etc.), but also present in many (a dozen or more) Atlantic stony coral genera and at least 8 *Acropora* species from the Great Barrier Reef. A subclade (B1) has been found in Hawaiian *Aiptasia* anemones and stony coral *Pocillopora damicornis* . Ex : *Symbiodinium pulchrorum*.

## Clade "C"

- Clade C is difficult to characterize, though Atlantic Clade C zooxanthellae are found in deeper water, while bleaching is often noted in Pacific corals containing Clade C symbionts. Generally, most Clade C zooxanthellae/corals inhabit tropical latitudes.Ex *Symbiodinium goreaui*

## Clade D

- Phylotype "D" Relatively resistant to bleaching (in comparison to many Clade C phylotypes), and, in fact, often found in areas that have suffered recent, severe bleaching episodes and hot environments.

## Clade E

- This clade is not known to occur in corals. Those zooxanthellae listed as Clade E in Toller et al., (2001) have been reclassified as Clade D. *Symbiodinium muscatinei* and *S. californium* (from the anemone *Anthopleura*) are sometimes listed as belonging to Clade E; they are listed as Clade B

## Clade "F"

- Normally found in foraminiferans, they not tolerant of high light intensity. Ex *Symbiodinium kawagutii*.

## Clade G

- Clade G has recently been found in soft corals (van Oppen, 2005a), stony corals (van Oppen 2005b) and giant sea anemones

# Why Are Some Zooxanthellae Resistant to Bleaching?

- **Protection from UV Radiation.** *some* zooxanthellae are able to protect themselves from ultraviolet radiation by production of mycosporine-like amino acids.
- **Protection from Intense Light.** Some zooxanthellae are able to produce and incorporate xanthophylls to protect themselves from high light intensity.
- **Thylakoid Membrane Composition** the lipid saturation of the hydrophilic thylakoid membrane within the chloroplast determines resistance to compromise.
- **Absorption of Heat** It found that darker pigmented corals can potentially gain radiant heat and become warmer than the surrounding water temperature. Obviously this could make the zooxanthellae potentially more susceptible to a bleaching event

# Zooxanthellae-Coral Reef

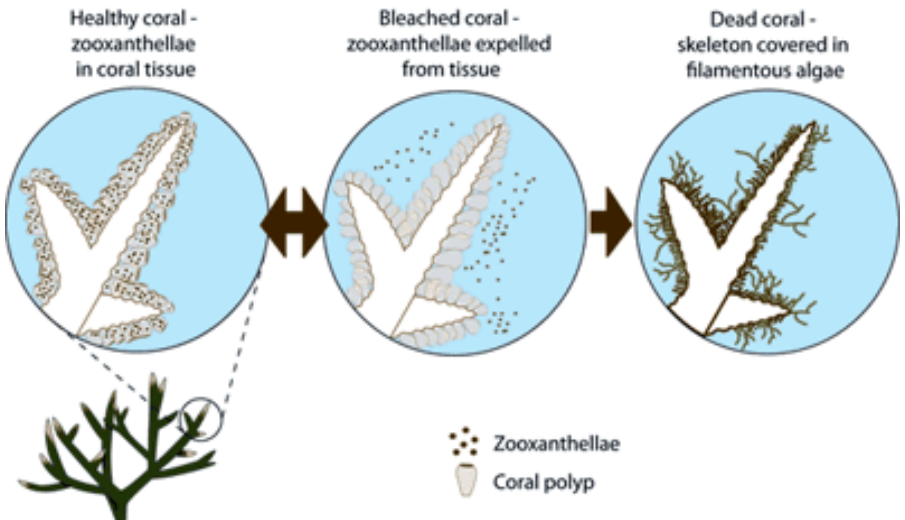
- Zooxanthellae are ubiquitous and critical members of coral reef ecosystems
- They are normally abundant, with healthy reefs typically containing $>10^9$ cells perm$^2$
- Zooxanthellae can be regarded as keystone species on coral reefs

# Zooxanthellae-Coral Symbiosis

- The algae gives off oxygen and other nutrients that the coral polyp needs to live. The presence of algal symbionts drives rapid calcification in the host organism. Excess products of photosynthesisare translocated to host as glycerol, glucose and alanine.
- The polyp gives the algae CO2 and a home. Pigments in zooxanthellae also give corals their beautiful orange, red, purple, and yellow colors. In return, the algae utilizes the host's nitrogenous wastes and acetate.

# The treats

- Coral bleaching
  - in which reef corals and other zooxanthellate hosts lose their algal symbionts (or experience a reduction in their per-cell pigment concentrations) and become pale or white
- Ocean acidification resulting in declining rates of coral calcification, the role of algal symbionts in influencing the response of their calcifying hosts



# The adaptation

- The Adaptive Bleaching Hypothesis (ABH) suggests that if the loss of Zooxanthellae occurs due to environmental change, the host organism forms a new symbiotic relationship with a different type of Zooxanthellae. These new endosymbionts are believed to be better adapted to the new environment.
- An abundance of Zooxanthellae that are thermally tolerant makes corals (The host) adapt to high temperatures

- Thank You