Educational & Instructional Figures, Tables, & Diagrams

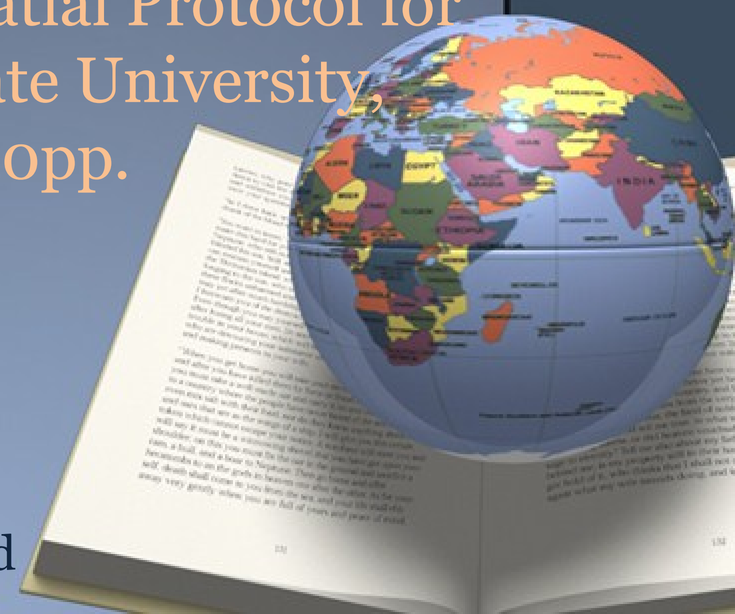
Adapted, Created, & Designed

by Jennifer A. Lentz

Informative Figures & Tables

The following figures were created by Jennifer Lentz and were used in Jennifer's Dissertation:

Lentz, JA (2012) Developing a Geospatial Protocol for Coral Epizootiology. Louisiana State University, Doctoral Dissertation. 320pp.



Note: all content adapted from other sources is cited

Table 2.3 (page 15)

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"**Table 2.3** Anthropogenically Induced Environmental Changes"

"Note: the above table was adapted from Tables 1, 2, and 3 on pages 5459 and 5461 of Western 2001"

References

Western D (2001) Human-modified ecosystems and future evolution. PNAS 98:5458-5465

Characteristics of intentionally modified ecosystems

- High natural resource extraction
- Short food chains
- Food web simplification
- Habitat homogeneity
- Landscape homogeneity
- Heavy use of herbicides, pesticides, & insecticides
- Large importation of non-solar energy
- Large importation of nutrient supplements
- Convergent soil characteristics
- Modified hydrological cycles
- Reduced biotic & physical disturbance regimes
- Global mobility of people, goods, & services

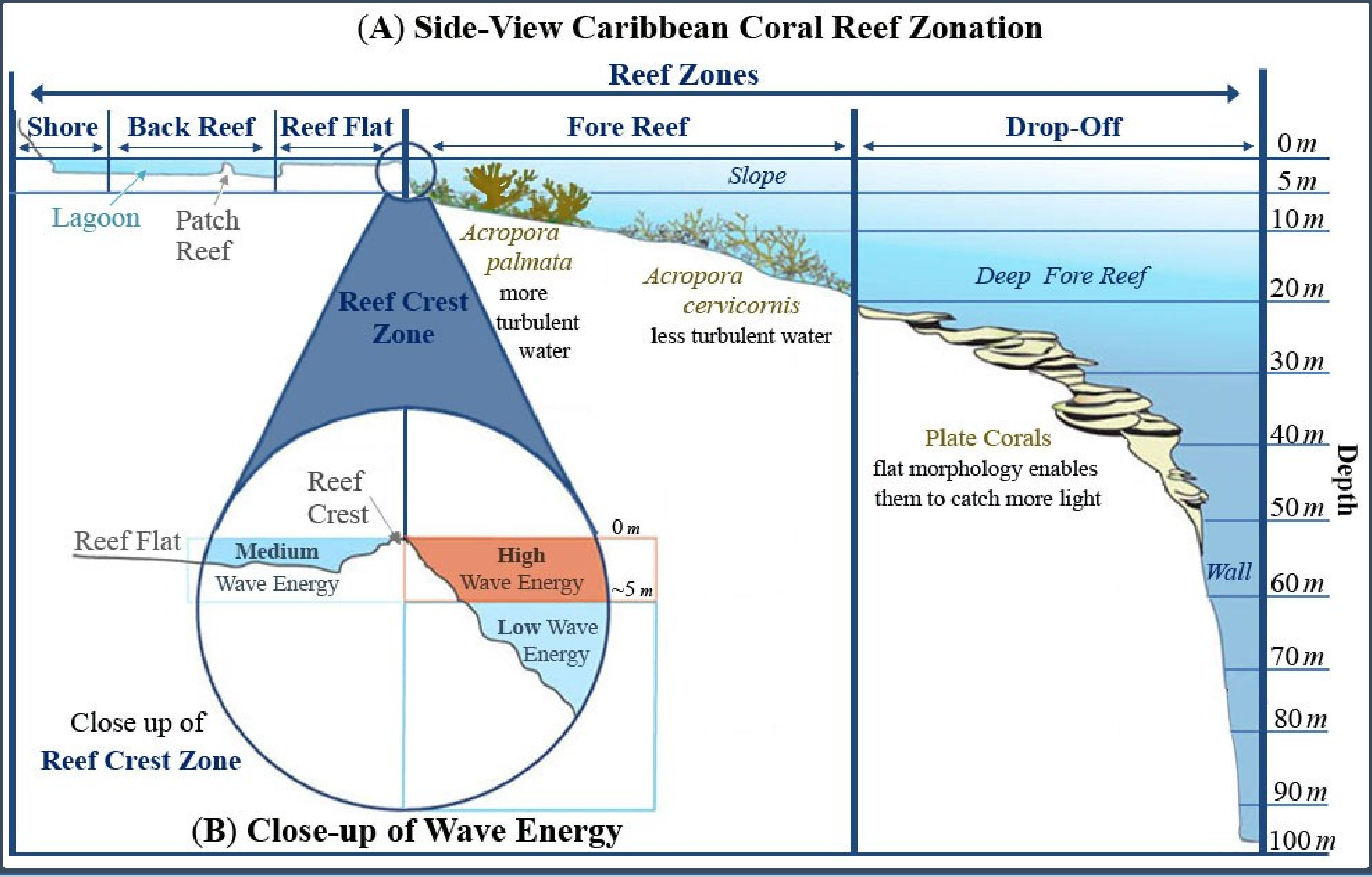
Ecosystem side-effects of human activity

- Habitat & species loss (including conservation areas)
- Truncated ecological gradients
- Reduced ecotones (transition zone between ecosystems)
- Low alpha diversity
- Loss of soil fauna
- Simplified predator–prey, herbivore–carnivore, & host–parasite networks
- Low internal regulation of ecosystems due to loss of keystone agents
- Side effects of fertilizers, pesticides, insecticides, & herbicides
- Invasive nonindigenous species, especially weeds & pests
- Proliferation of resistant strains of organism
- New & virile infectious diseases
- Genetic loss of wild & domestic species
- Overharvesting of renewable natural resources
- High soil surface exposure & elevated albedo
- Accelerated erosion
- Nutrient leaching & eutrophication
- Pollution from domestic & commercial wastes
- Ecological impact of toxins & carcinogenic emissions
- Atmospheric & water pollution
- Global changes in lithosphere, hydrosphere, atmosphere, & climate

Some ecological consequences of human activity on ecosystem processes

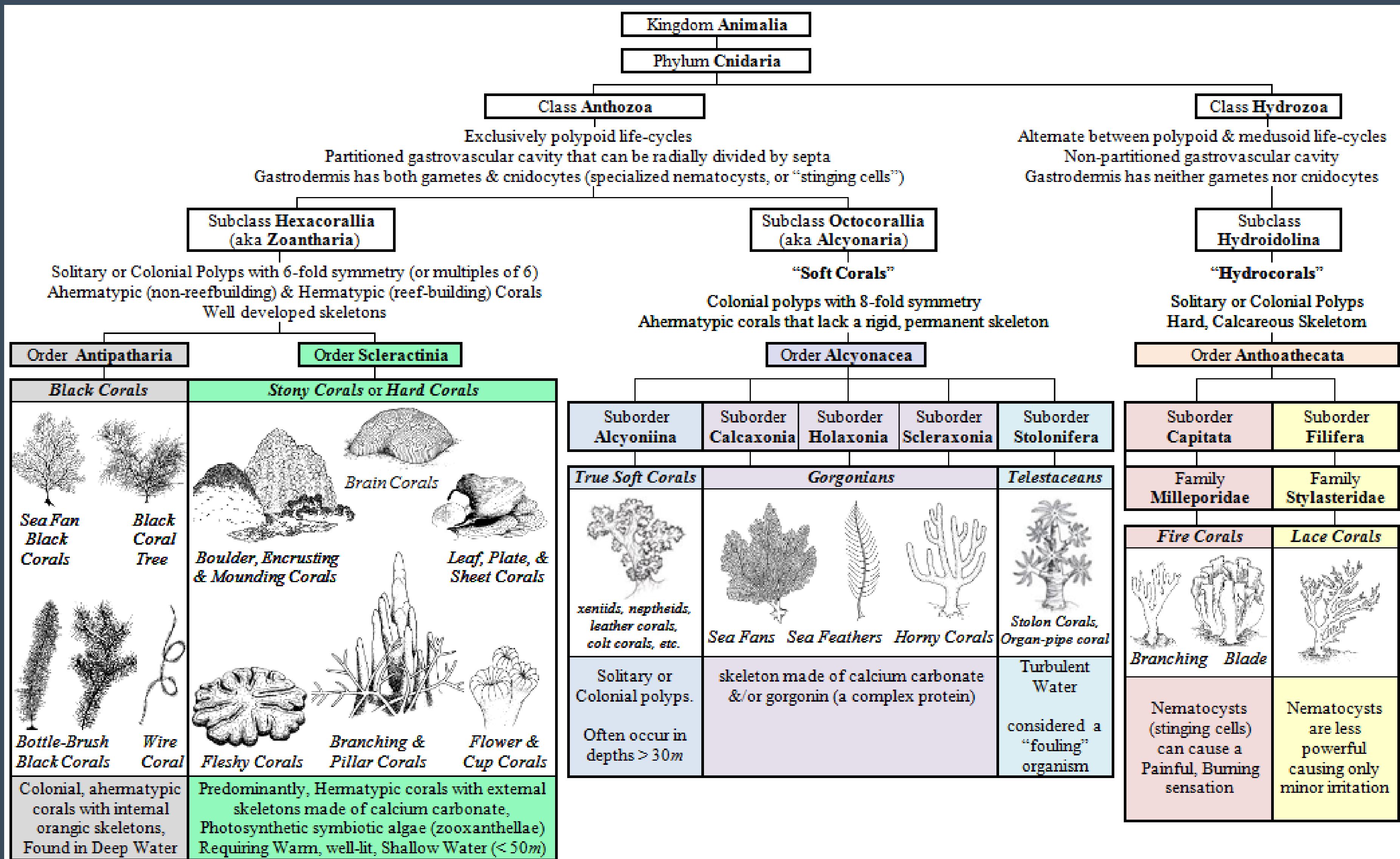
- Ecosystem structure
- Loss of biodiversity
- Structural asymmetry & downsizing of communities
- Loss of keystone species and functional groups
- Ecosystem processes
- Low internal regulation
- High nutrient turnover
- High resilience
- Low resistance
- Low variability
- Low adaptability
- Ecosystem functions
- High porosity of nutrients & sediments
- Loss of productivity
- Loss of reflectance
- Global processes
- Modified biogeochemical cycles
- Atmospheric change
- Accelerated climatic change

Figure 3.1 (page 25)



"**Figure 3.1** Reef Zonation. (**A**) A side-view of some of the common types of reef zones found in the Caribbean. (**B**) A close-up of the different types of wave energy generally found on either side of the reef crest. Note: this figure was adapted from the diagram on the following website: *http://media.beautifuloceans.com/course1/pic/1.1_CoralReef_Zonation_800pix.jpg*."

Figure 3.2 (page 29)



"**Figure 3.2** Taxonomic classifications, characteristics, and depictions of common types of corals. Note: the above taxonomic classifications and characteristics were based on the following sources: Lutz (1986); Fautin & Romano (1997,2000); Fautin et al. (2000); Humann and Deloach (2002); Romano and Cairns (2002); Rose (2009); Sheppard et al. (2009); OBIS (2011). The illustrations are from Humann & Deloach's (2002) "Reef Coral Identification: Florida Caribbean Bahamas" book."

Figure 3.3 (page 30)

"**Figure 3.3** Coral reefs and the basic anatomy of hermatypic corals. (**A**) An example of a coral reef ecological community. (**B**) This is a close-up of the *Montastrea cavernosa* coral shown in **A**, representing an individual coral colony. (**C**) A close-up of *M. cavernosa* polyps depicting the difference between the visual appearance of an open polyp (right) and a closed polyp (left). (**D**) A cross-sectional diagram depicting the major anatomical elements associated with scleractinian, hermatypic corals. (**E**) Cross-sectional diagram of the coral holobiont, depicting the some common microbial inhabitants in relation to the anatomy of a scleractinian polyp. The microbes are not drawn to scale. Note: the photograph shown in **A** (and **B**) was taken in Puerto Rico by NOAA's Biogeography Team, Center for Coastal Monitoring (*http://www8.nos.noaa.gov/biogeo_public/habitat_photos.aspx*). The photograph of the M. cavernosa polyps shown in **C** was taken by Steve Vollmer's lab, and is available online at: *http://nuweb5.neu.edu/vollmerlabwp/category/potential-students/*. The diagram shown in **D** was adapted from Geoff Kelly's figure in Veron (2000), and the diagram shown in **E** was adapted from Figure 1, on page 356 of Rosenberg et al. (2007b)."

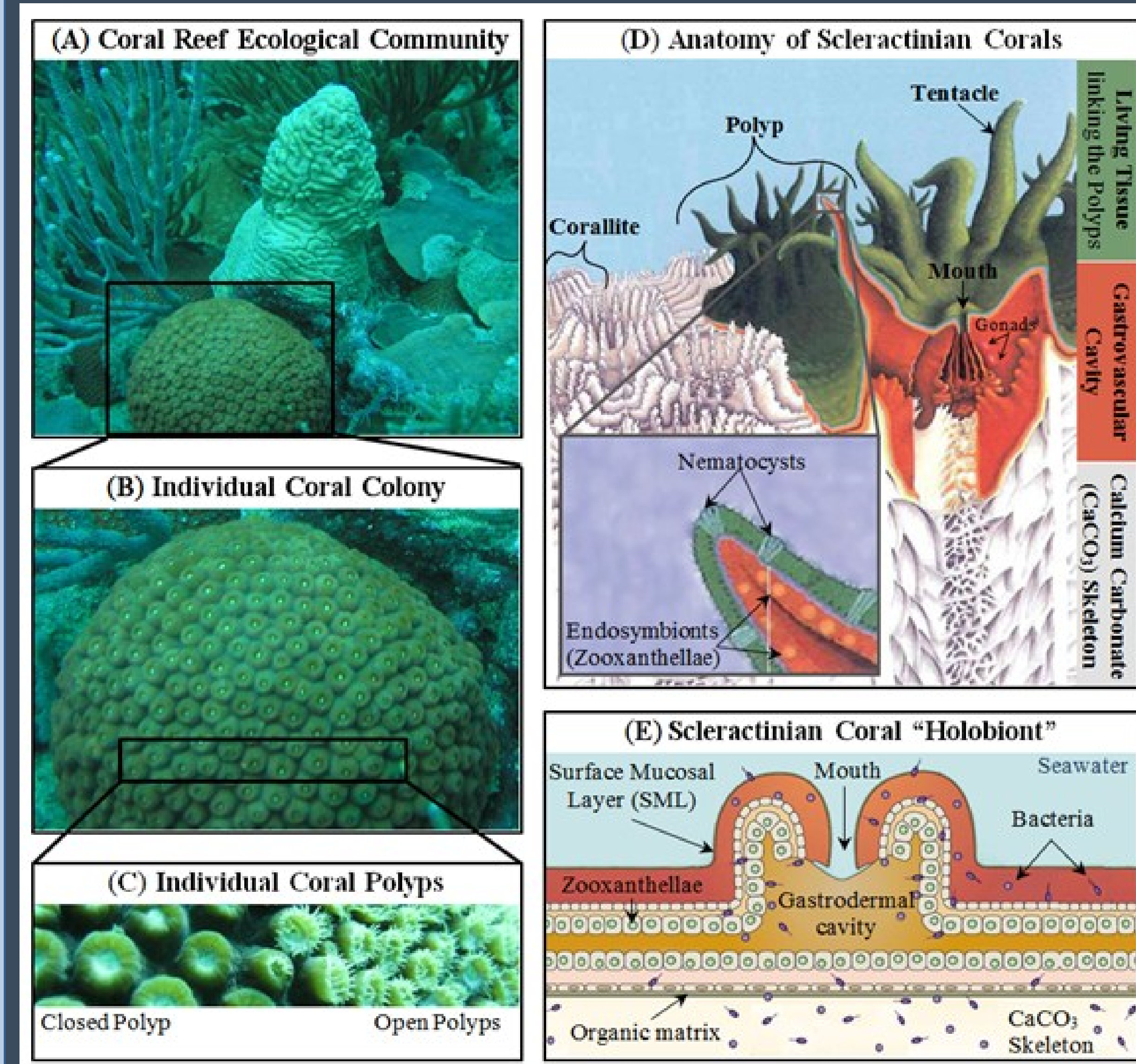
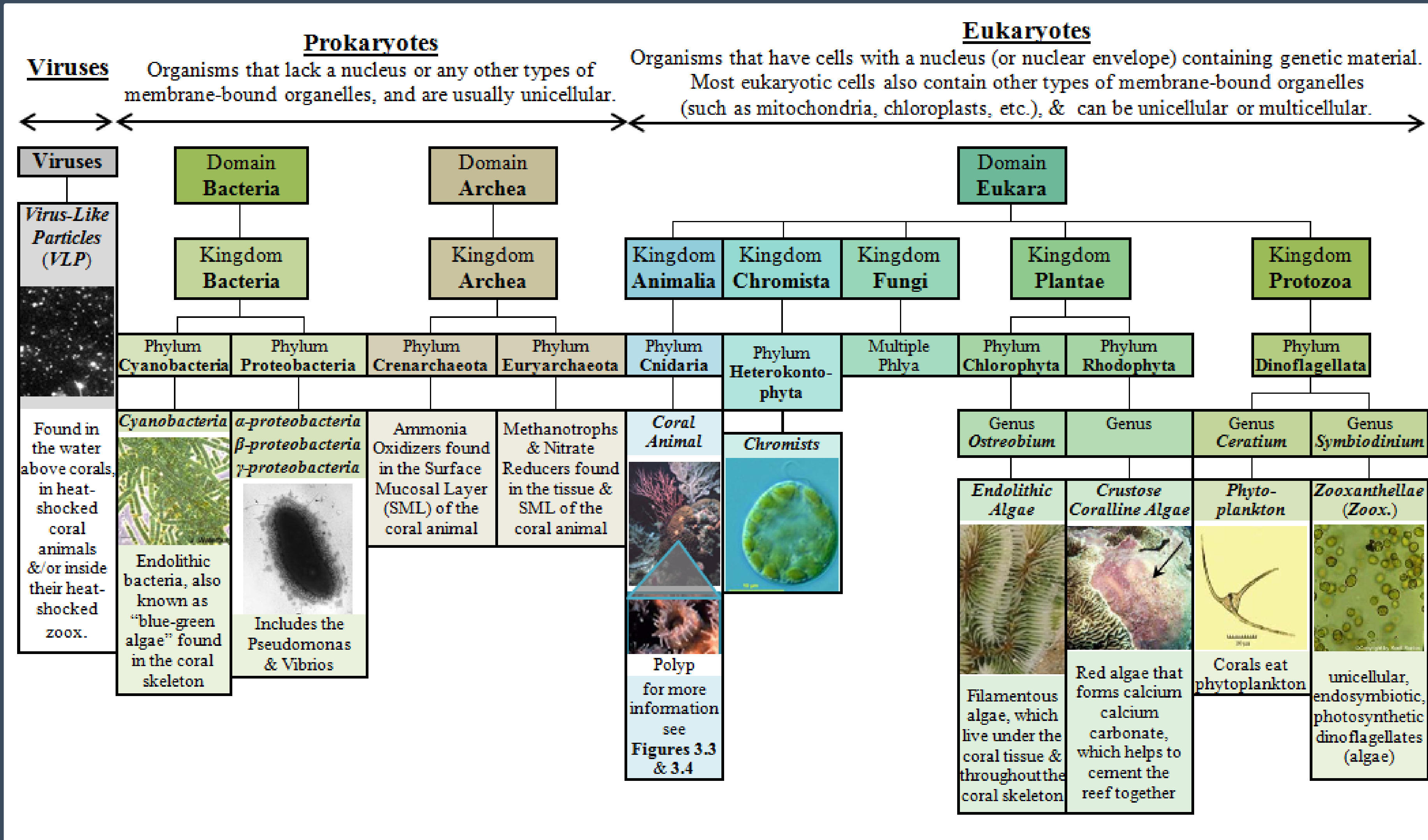
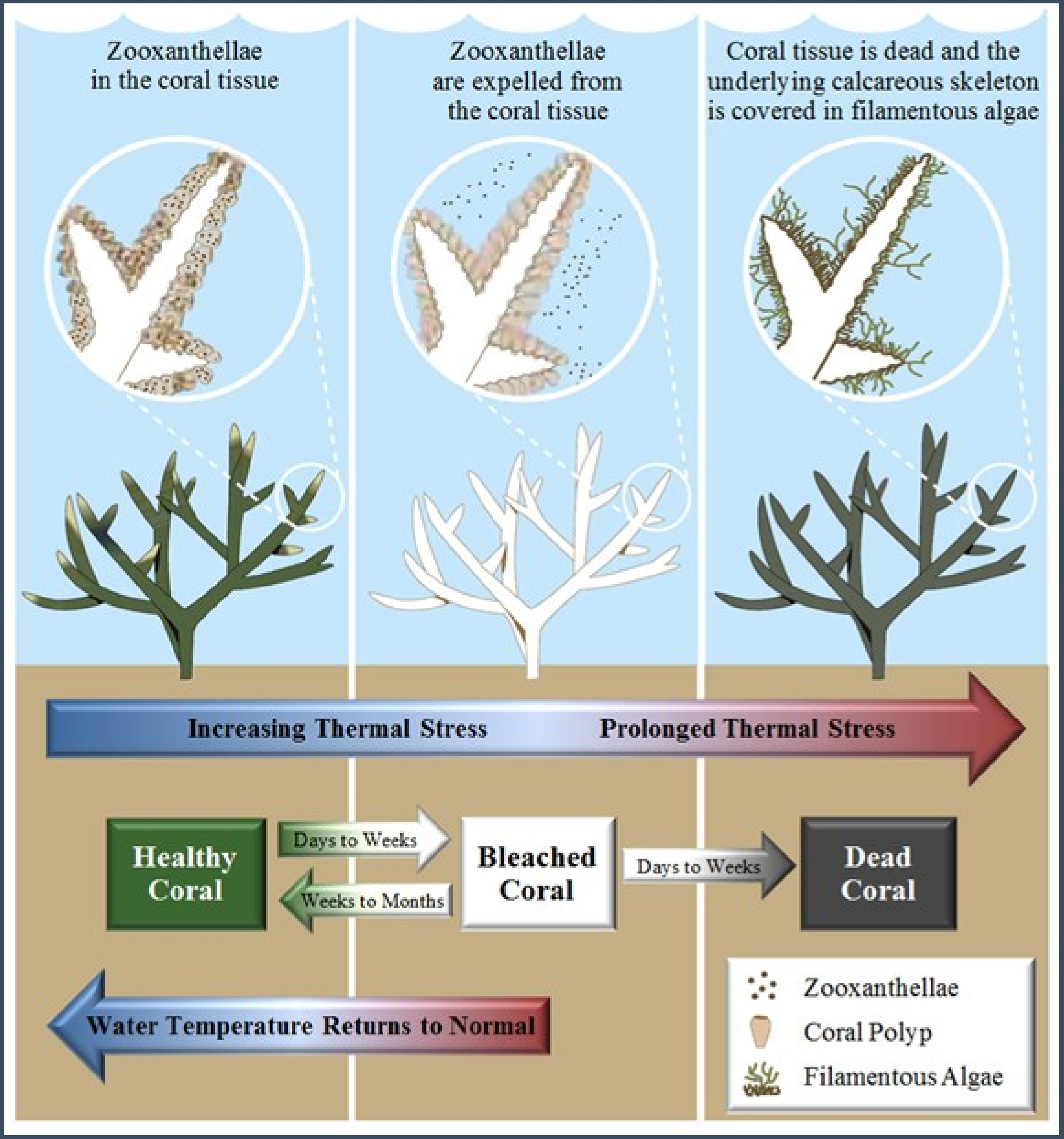


Figure 3.4 (page 33)



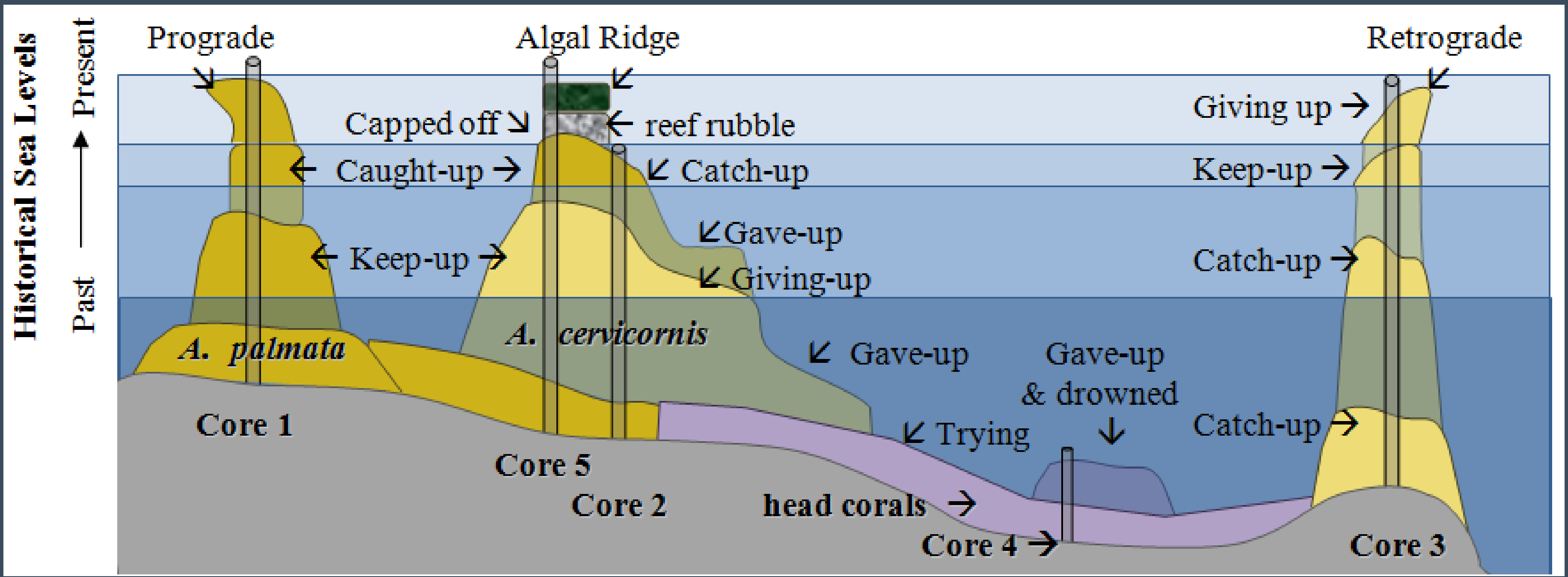
"**Figure 3.4** Some of the organisms (both macro- and micro-) known to make up the coral Holobiont (Shashar et al. 1997; Baker 2003; Kellogg 2004; Wegley et al. 2004; Wilson et al. 2005; Beman et al. 2007; Rosenberg et al. 2007a; Siboni et al. 2008; Lins-de-Barros et al. 2010; OBIS 2011). Note: the virus and endolithic algae images were taken from Figure 1 on page 147 of Rosenberg et al. (2007b); all other images are from NOAA's Coral Reef Information System (CoRIS) website (*www.coris.noaa.gov/*)."

Figure 3.5 (page 42)



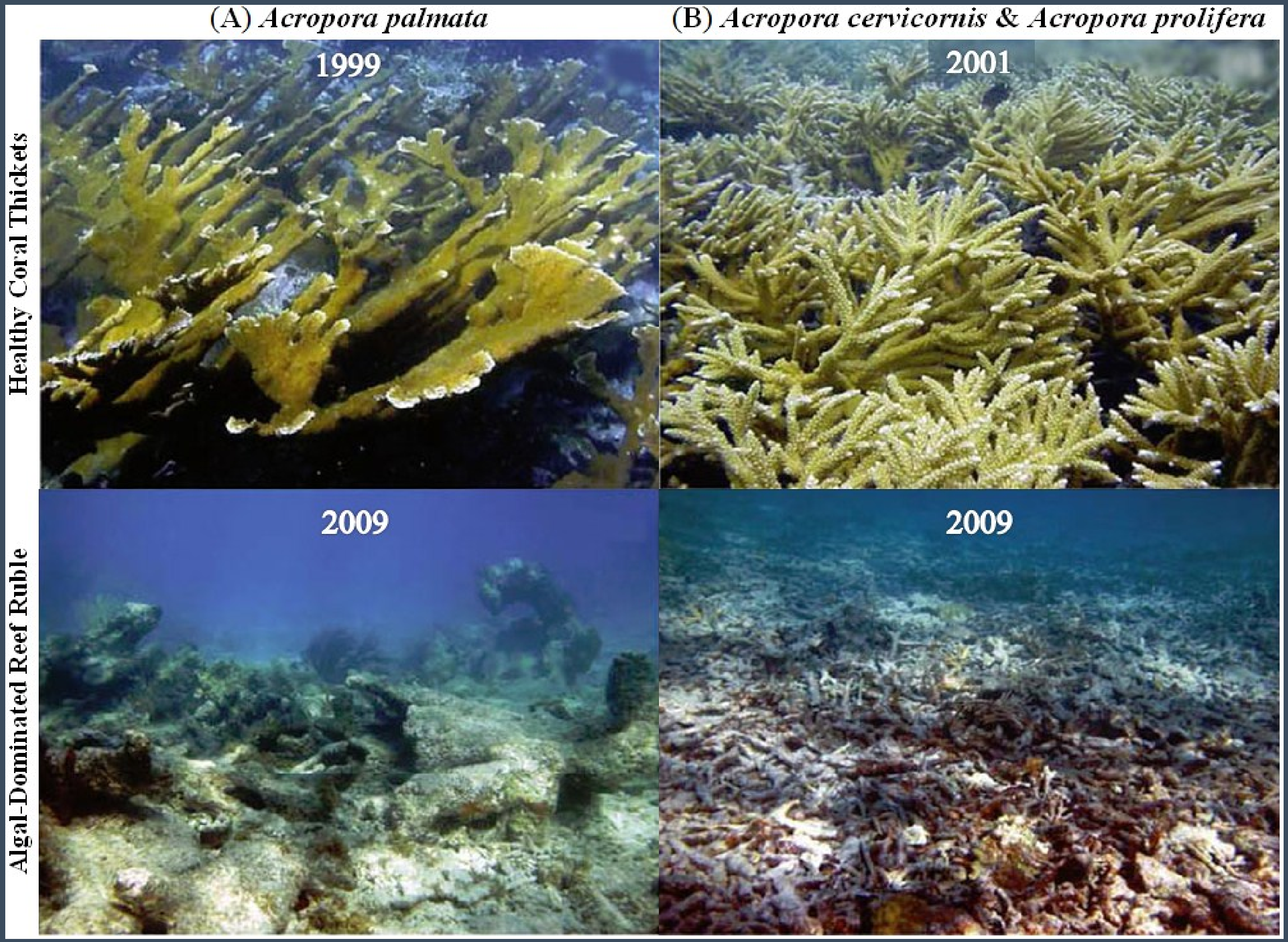
"**Figure 3.5** Diagram of thermal coral bleaching. Note: this diagram was adapted from Figure 1.3 on page 7 of Marshall and Schuttenberg (2006)."

Figure 3.6 (page 54)



"**Figure 3.6** Diagram of the potential responses of various types of reefs to sea-level rise."

Figure 3.7 (page 58)



"**Figure 3.7** Time Series photographs depicting Caribbean *Acropora* species transitioning from healthy corals to algal-dominated, reef ruble in San Cristobal, Puerto Rico. (**A**) *Acropora palmata* in 1999 and 2009. (**B**) *Acropora cervicornis* and *Acropora prolifera* in 2001 and 2009. Note: the above figure was adapted from Figure 2 on page 555 of Bourne et al. (2009) with photographs taken by Ernesto Weil."

Figure 3.8 (pages 60-61)

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Figure 3.8 “Diseases known to affect the *Acropora* coral genus worldwide. The diseases shown on the top row (**A** – **C**) are known to only *Acropora* corals world-wide; while the diseases on the second row (**D** – **E**) appear to only affect Caribbean *Acropora* species, and the diseases on the bottom two rows (**F** – **K**) affect *Acropora* in the Indo-Pacific. (**A**) Thermal Bleaching on *A. millepora* at the Great Barrier Reef, Australia. (**B**) Growth Anomalies (GA) on branching *Acropora* at the Great Barrier Reef, Australia. (**C**) Skeletal Anomaly (SKA) on *A. palmata*. (**D**) The two types of White-Band Disease (WBD), both depicted on *A. palmata*; WBD Type I is depicted in $\mathbf{D_1}$ and WBD Type II is depicted in $\mathbf{D_2}$. (**E**) White-Pox Disease (WPD or WPox), also known as Acroporid Serratiosis (APS), on *A. palmata*. (**F**) Black-Band Disease (BBD) on an *Acropora* species. (**G**) Brown-Band Disease on a branching *Acropora* species at the Great Barrier Reef, Australia. (**H**) Skeleton Eroding Band Disease (SEB) on *A. intermedia* at the Great Barrier Reef, Australia. (**I**) White Syndrome (WS) on a plating *Acropora* species at the Great Barrier Reef, Australia. (**J**) Yellow-Band Disease (YBD) on *A. pharaonis*. (**K**) BBD and SEB on the same colony of *A. muricata* at the Great Barrier Reef, Australia. Note: the above disease depictions were taken from the following sources: (A) taken from Figure 2 on page 1361 of Jones et al. (2008); (**B,G,H, I**) photos were taken by Betty Willis and published in Figure 8 on page 183 of Harvell et al. (2007); (**C** and **D1**) taken from Figure 3 on page 282 of Sutherland et al. (2004); (**D2**, **E**) photos were taken by Ernesto Weil and published in Figure 3 on page 178 of Harvell et al. (2007); (**F**) taken from page 29 of Raymundo et al. (2008); (**J**) taken from page 22 of Korrubel and Riegl (1998); and (**K**) taken from Figure 4 on page 47 of Page and Willis (2006).”

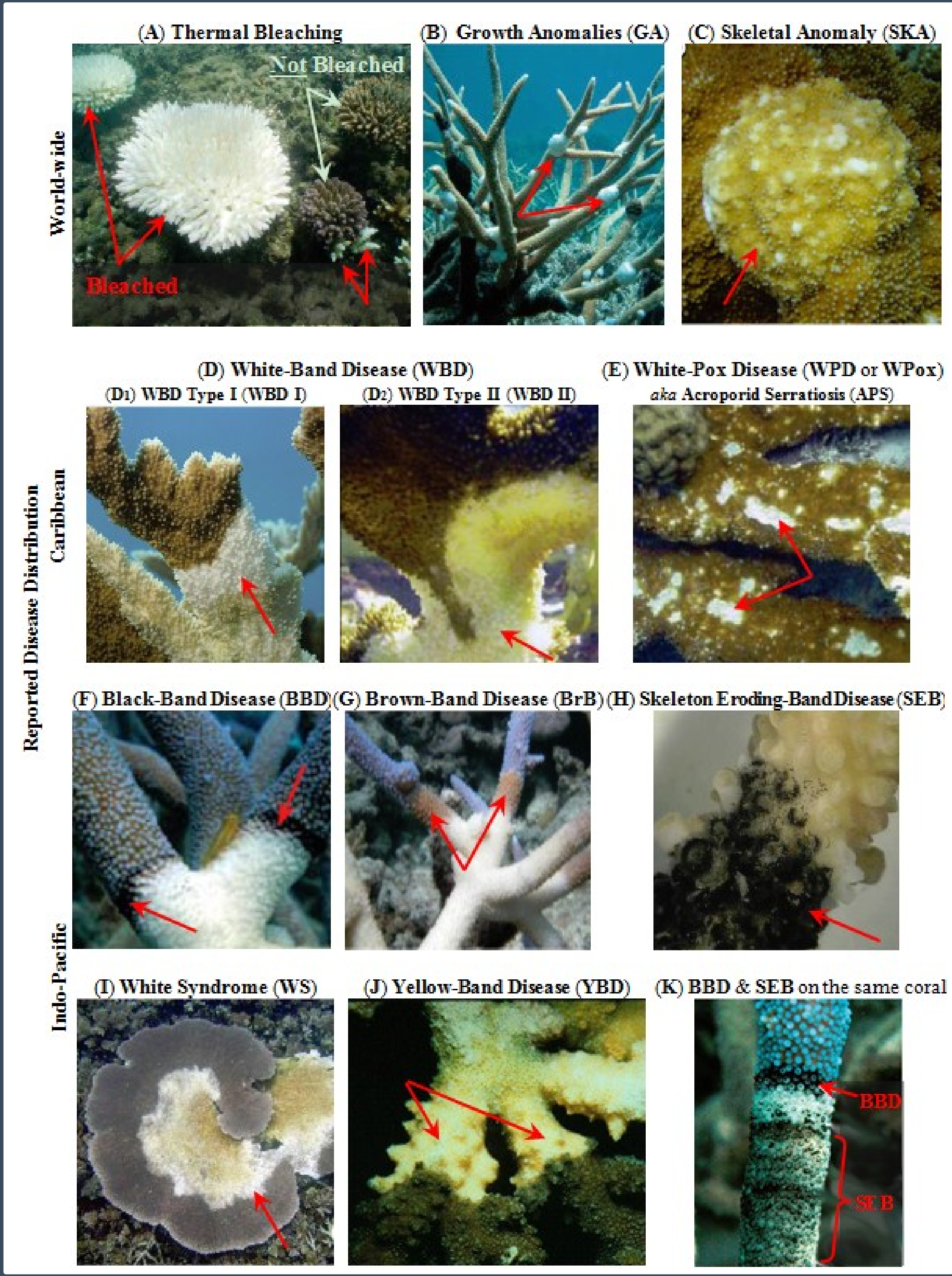

Table 3.1 (pages 63)

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"Table 3.1 Important Medical Terminology Related to Coral Diseases"

"Note: the above definitions were adapted slightly from the 28th Edition of Stedman's Medical Dictionary (2006)."

Apoptosis	Programmed cell death
Atrophy	A wasting of tissues, organs, or the entire body, as from death & reabsorption of cells, diminished cellular proliferation, decreased cellular volume, pressure, ischemia, malnutrition, lessened function, or hormonal changes
Defense Mechanism	A physiological self-protecting response of an organism to a harmful stimuli
Epizootiology	The study of the distribution and determinants of health-related states or events in specified animal populations, and the application of this study to control health problems Note: The term "Epidemiology" should be used only when referring to human populations
Etiology	The science and study of the causes of disease and their mode of operation
Histology	The science concerned with the minute structure of cells, tissues, & organs in relation to their function
Histopathology	Science or study dealing with the cytologic & histologic structure of abnormal or diseased tissue
Hyperplasia	An increase in the number of normal cells in a tissue or organ, not due to tumor formation
Hypertrophy	General increase in bulk or a part of an organ, not due to tumor formation
Infectious	A disease capable of being transmitted from patient to patient, with or without actual contact
Lesion	A wound or injury; a pathologic change in the tissues. One of the individual points or patches of multifocal disease
Necrosis	Pathologic death of one or more cells, or of a portion of tissue or organ, resulting from irreversible damage
Neoplasia	The pathologic process that results in the formation & growth of a neoplasm (tumor)
Panzootic	An epizootic occurring on a global scale
Parasite	An organism that lives on or in another & draws its nourishment therefrom
Pathogen	Any virus, microorganism, or other substance causing disease
Opportunistic P.	an organism that is capable of causing disease only when the host's resistance is lowered
Pathology	The form of medical science & specialty practice concerned with all aspects of disease
Sign	Any abnormality indicative of disease, discoverable on examination of the patient; an objective indication of disease. Note: the term "symptom" refers to subjective indications of disease; consequently humans are the only type of animal that has *symptoms* associated with a given disease.
Stress	Reactions of the body to forces of a deleterious nature, infections, & various abnormal states that tend to disturb its normal physiologic equilibrium (homeostasis)
Stressor	An event or association that triggers a stress response
Susceptibility	Likelihood of an individual to develop ill effects from an external agent

Table 3.2 (pages 65)

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"Table 3.2 Comparing the *standard* medical definitions of "disease" and "syndrome" used by the most common medical dictionaries series both in print (Stedman's and Dorland's) and online (MedicineNet.com and MedlinePlus.com).

Medical Dictionary	Disease	Syndrome
Stedman (2006)	"1. An interruption, cessation, or disorder of a body, system, or organ structure or function. SYN illness, morbus, sickness. 2. A morbid entity ordinarily characterized by two or more of the following criteria: recognized etiologic agent(s), identifiable group of signs and symptoms, or consistent anatomic alterations. SEE ALSO syndrome." (page 550)	"*This word is not properly applied to a solitary symptom or sign.* The aggregate of symptoms and signs associated with any morbid process, together constituting the picture of the disease. SEE ALSO disease." (page 1888)
Dorland (1994)	"any deviation from or interruption of the normal structure of function of any part, organ, or system (or combination thereof) of the body that is manifested by a characteristic set of symptoms and signs and whose etiology, pathology, and prognosis may be known or unknown." (page 478)	"[a] set of symptoms which occur together" (page 1632)
MedicineNet (2011)	"Illness or sickness often characterized by typical patient problems (symptoms) and physical findings (signs)."	"A set of signs and symptoms that tend to occur together and which reflect the presence of a particular disease or an increased chance of developing a particular disease."
MedlinePlus (2003)	"An impairment of the normal state of the living animal or plant body or one of its parts that interrupts or modifies the performance of the vital functions, is typically manifested by distinguishing signs and symptoms, and is a response to environmental factors (as malnutrition, industrial hazards, or climate), to specific infective agents (as worms, bacteria, or viruses), to inherent defects of the organism (as genetic anomalies), or to combinations of these factors : **SICKNESS, ILLNESS** —called also *morbus*; compare **HEALTH**"	"A group of signs and symptoms that occur together and characterize a particular abnormality"

Figure 3.9 (pages 69-70)

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Figure 3.9 "Types of information that should be recorded when describing disease lesions on corals in the field. Note: this figure summarizes the information provided in Work and Aeby's (2006) Tables 1-2 and Figure 1 on pages 156-157. The depictions of coral types shown in **1(a-e)** are from page 485 of Veron and Wallace (1984) and are available online at: *http://biophysics.sbg.ac.at/coral/morfacro.htm*; the depiction of the "free-living" coral type shown in **1(f)** was taken from a Tiwan study that is available online at: *http://163.26.138.2/dyna/webs/index.php?account=admin&id=22&mod_area=15*; the coral image used for **2(a-f)**, **3(a-d)**, and **8(a-k)** was adapted from the Brain Coral depicted on page 87 of Humann and Deloach (2002); and last the images shown in **4-7** were taken from Figure 1 on page 157 of Work and Aeby (2006)."

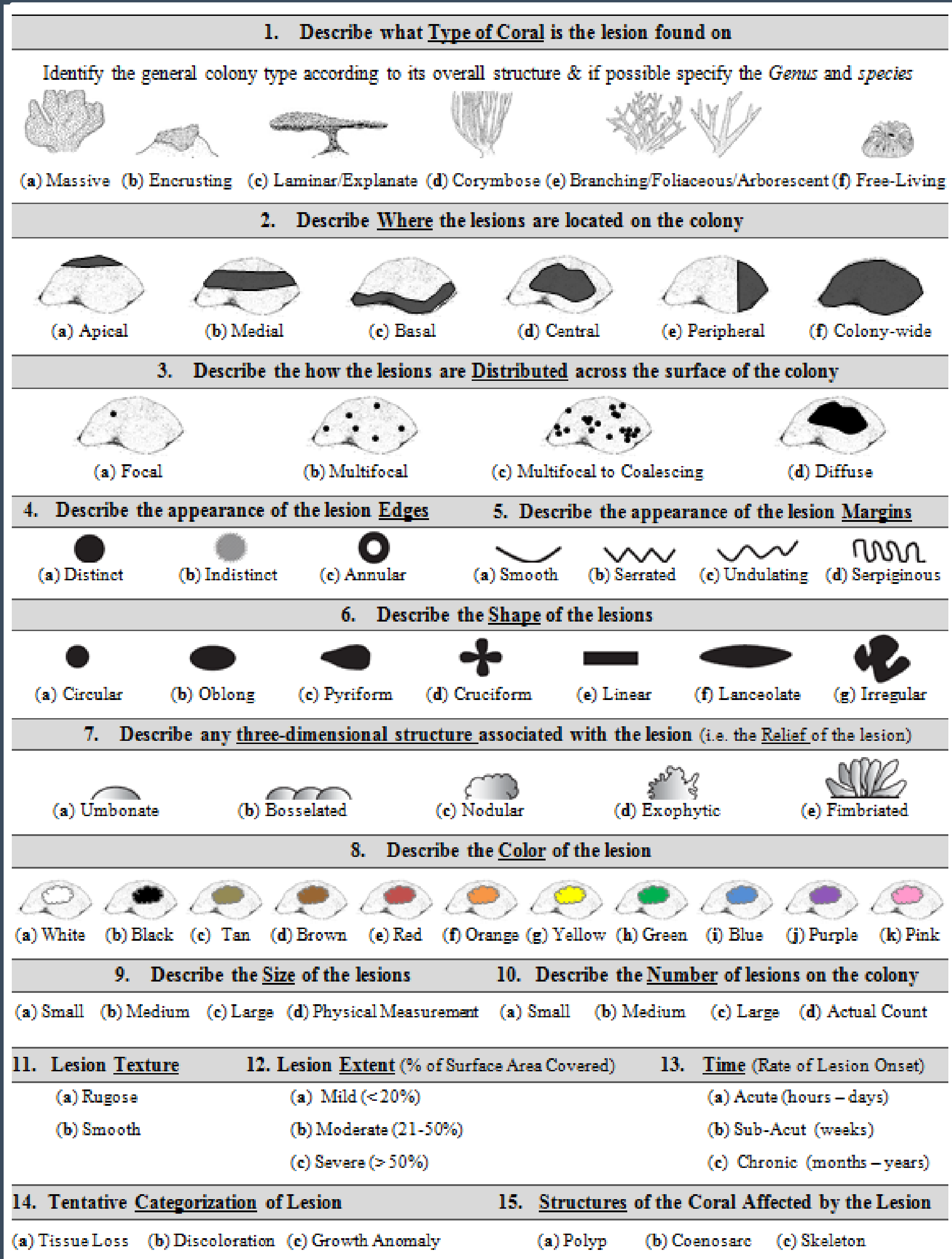
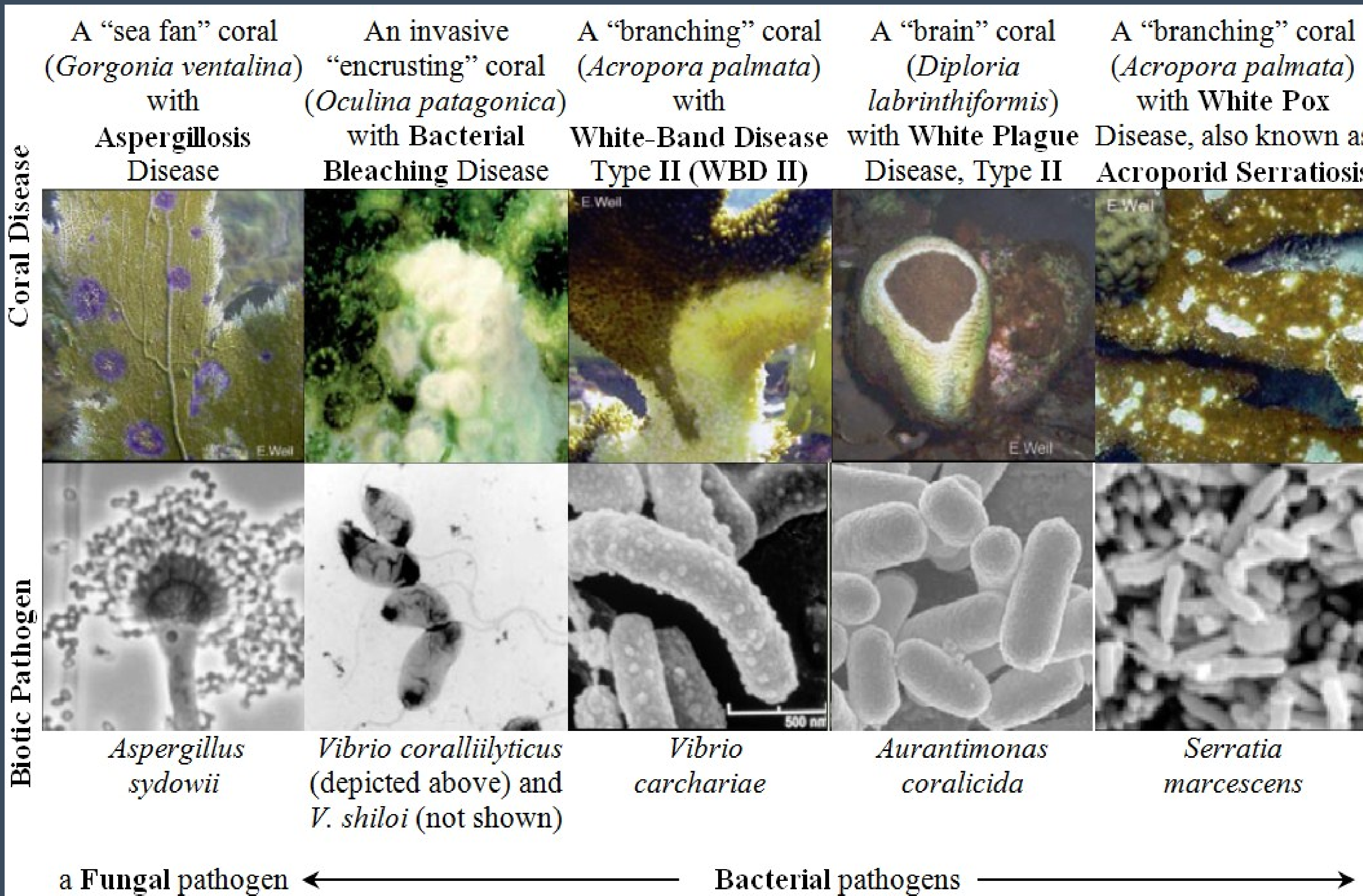


Figure 3.10 (page 72)



"**Figure 3.10** The five coral diseases in which Koch's postulates have been fulfilled, indicating that each is a biotically induced disease caused by the microbial pathogen indicated below. Note: this figure was adapted from Figure 3 on page 178 of Harvell et al. (2007)."

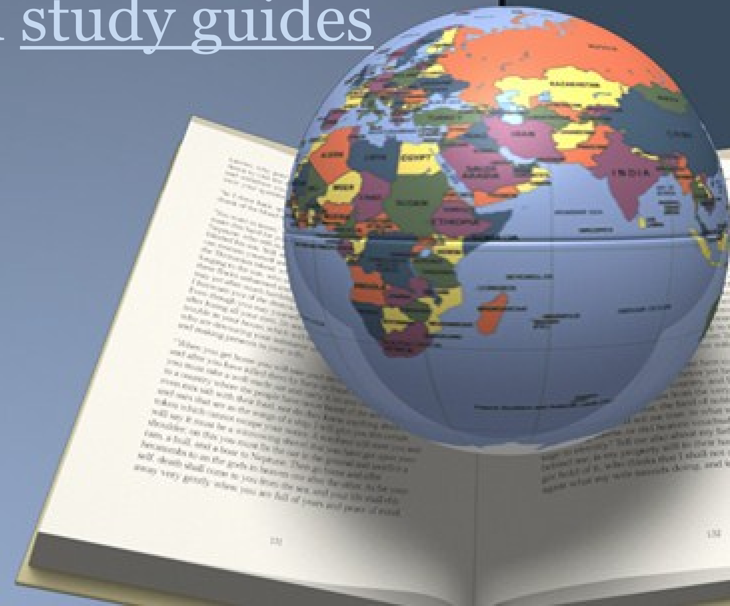
Table 3.3 (page 75)

- whether or not diseases cluster
- distance scales of disease clusters
- whether these clusters are real or just artifacts of high underlying population density
- where clusters are occurring
- intensity and density information
- spatial prevalence information
- areas with high and/or low clustering levels
- the presence of statistically significant clustering areas
- the ability to take spatial patterns and compare them to environmental factors
- the ability to integrate spatial models with mathematical and/or predictive models
- the ability to locate and investigate and protect areas with increased risk

"**Table 3.3** Examples of types of information regarding coral epizootiology that can *only* be attained using geospatial analysis."

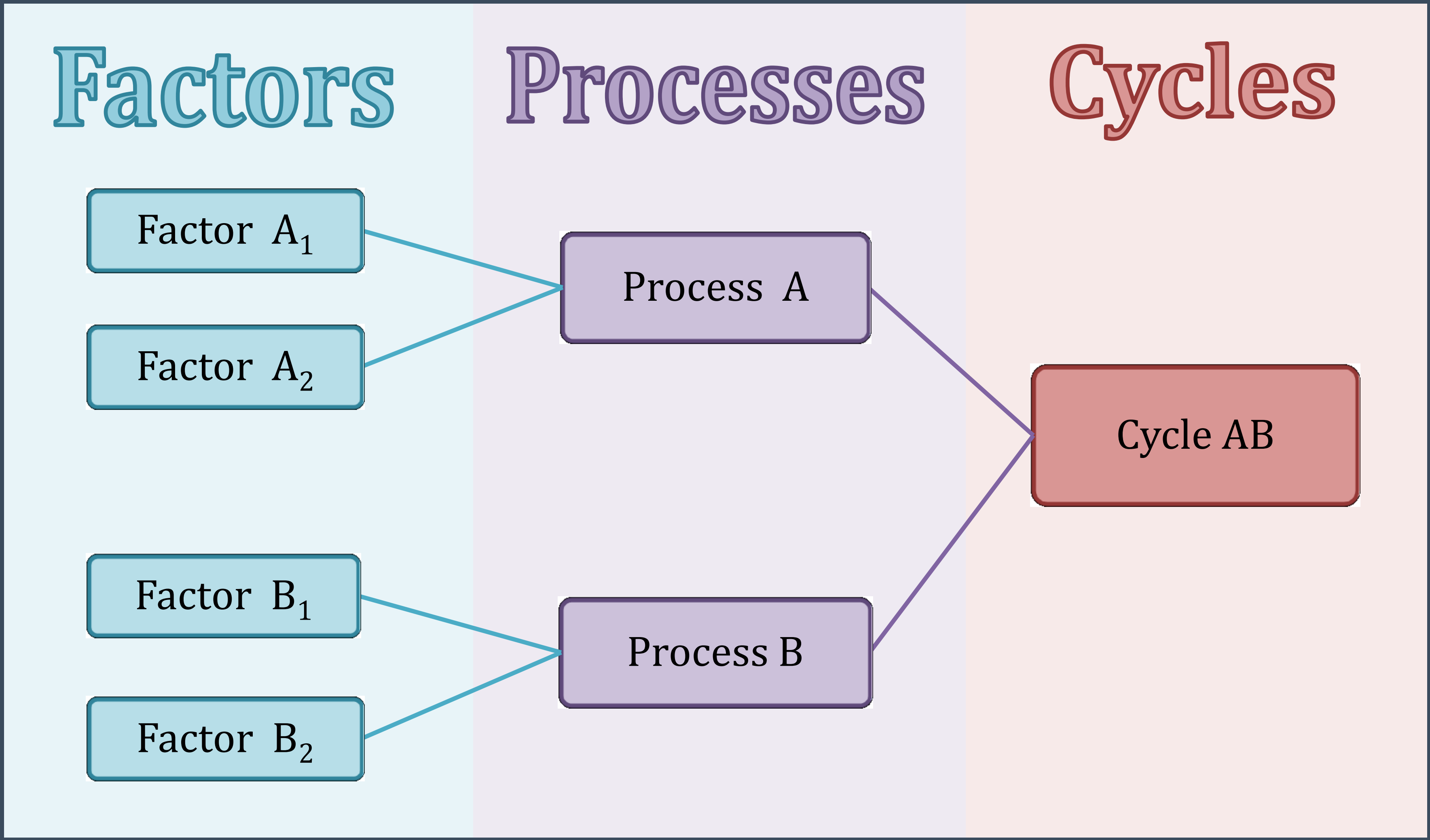
Educational & Informative Figures & Tables

The following slides were created by Jennifer Lentz and were used in her course notes and study guides



Note: content adapted from other sources is cited

Factors, Processes, & Cycles



Adapted from Dr. Gambrell's 2009 course notes for
Biogeochemistry of Wetland Soils & Sediments (OCS 7165)

Factors, Processes, & Cycles

Algal Blooms

Favorable Factors

Factor 1

Favorable water temperature

Factor 2

Plenty of Available Phosphorous (P) & other nutrients

Factor 3

lack of toxic materials

Factor 4

Water turbidity is low

Process

Process

Algal Bloom

Unfavorable Factors

Factor 5

Sunlight limited reaching bayou due to dense tree canopy

Flooding a soil or sediment system will cause anaerobic conditions to develop (lack of dissolved oxygen due to oxygen being consumed by microbial respiration), yet you find a system where this is not true.

Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Factors, Processes, & Cycles

Anaerobic Processes

Favorable Factors

Factor 1

temperature favorable for microbial activity (O_2 consumption)

Factor 2

inorganic nutrients are available

Factor 3

flooding of soil or sediment is occurring

Process

Process

A number of anaerobic processes are occurring

Unfavorable Factors

Factor 4

Soil or sediment contains little organic matter (ex. beach sand)

Factor 5

high hydrologic energy with waves & tides force movement of oxygenated water through soil (beach sand) matrix

Establishment of an algae bloom when Phosphorous concentrations are above the "published" critical concentrations for a bloom

Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Factors, Processes, & Cycles

Contamination Degradation

Favorable Factors

Factor 1
Available energy source for microbes

Factor 2
Adequate soil temperature for microbes

Factor 3
other nutrients required for microbes are available

Factor 4
Soil is drained & is thus oxidized
→ favors greater microbial activity

Process

Process
Contaminant Degradation

Unfavorable Factors

Factor 5
Contaminant concentration is so high it is toxic to microbes
(ex. **Creosote** bush)

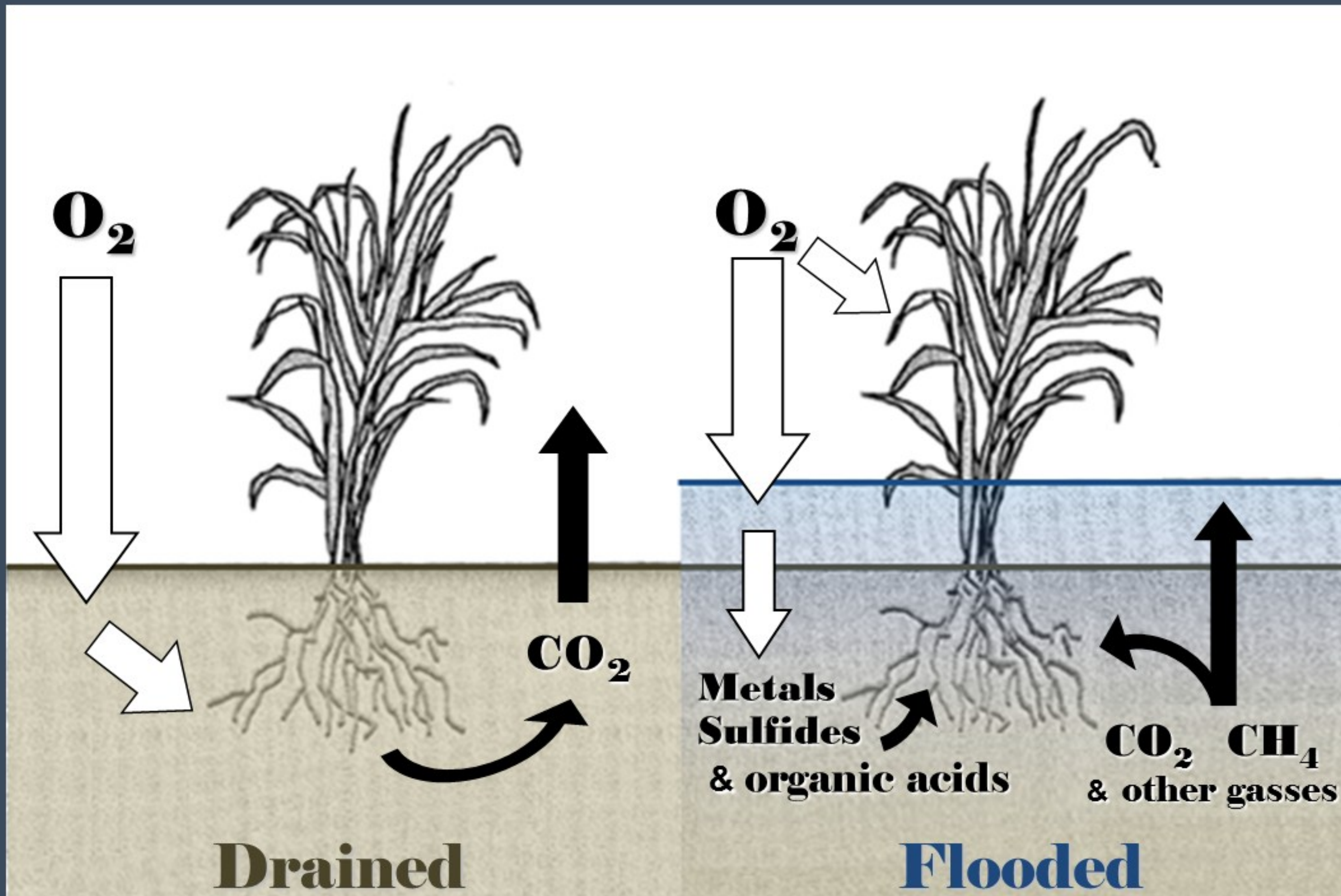
Microbial Activity should degrade organic contaminant in soil

Creosote bush roots produce chemicals that inhibit the growth of other plants & are toxic to the subsurface microbes → Sterol sediment.

Thus, high toxicity prevents the degradation of organic contaminants by killing the microbes which would ordinarily have broken down the contaminants

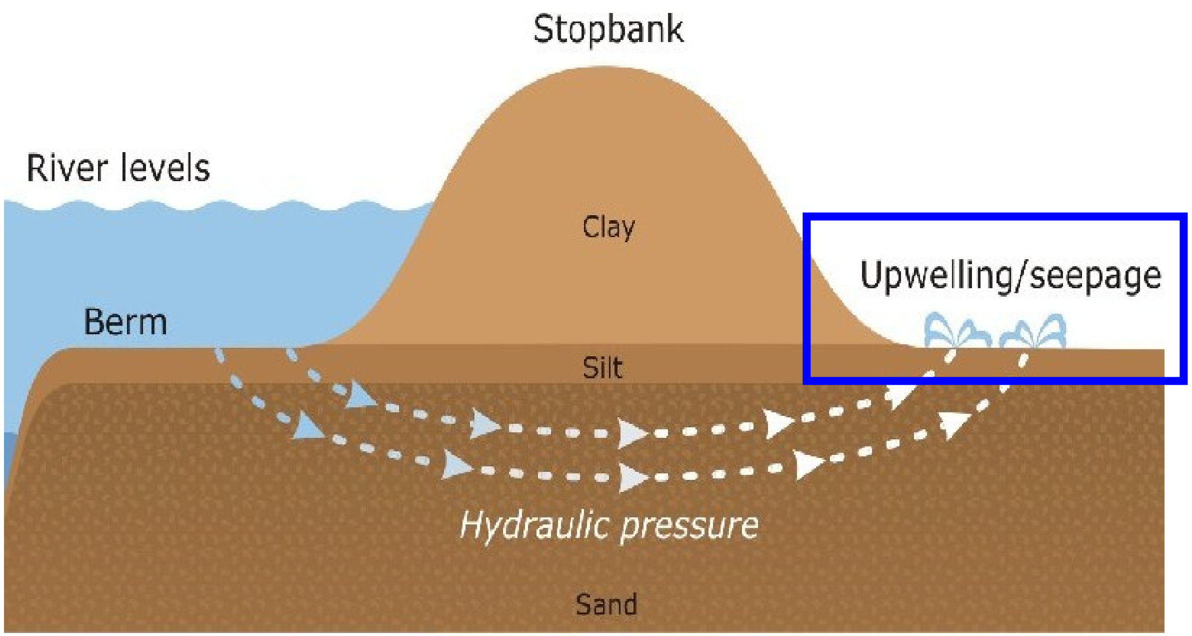
Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Gas Exchange between Drained & Flooded Soils



Adapted from Figure 6.1 on page 186 of Reddy & DeLaune (2008)

Hydrology (Sand Boils)

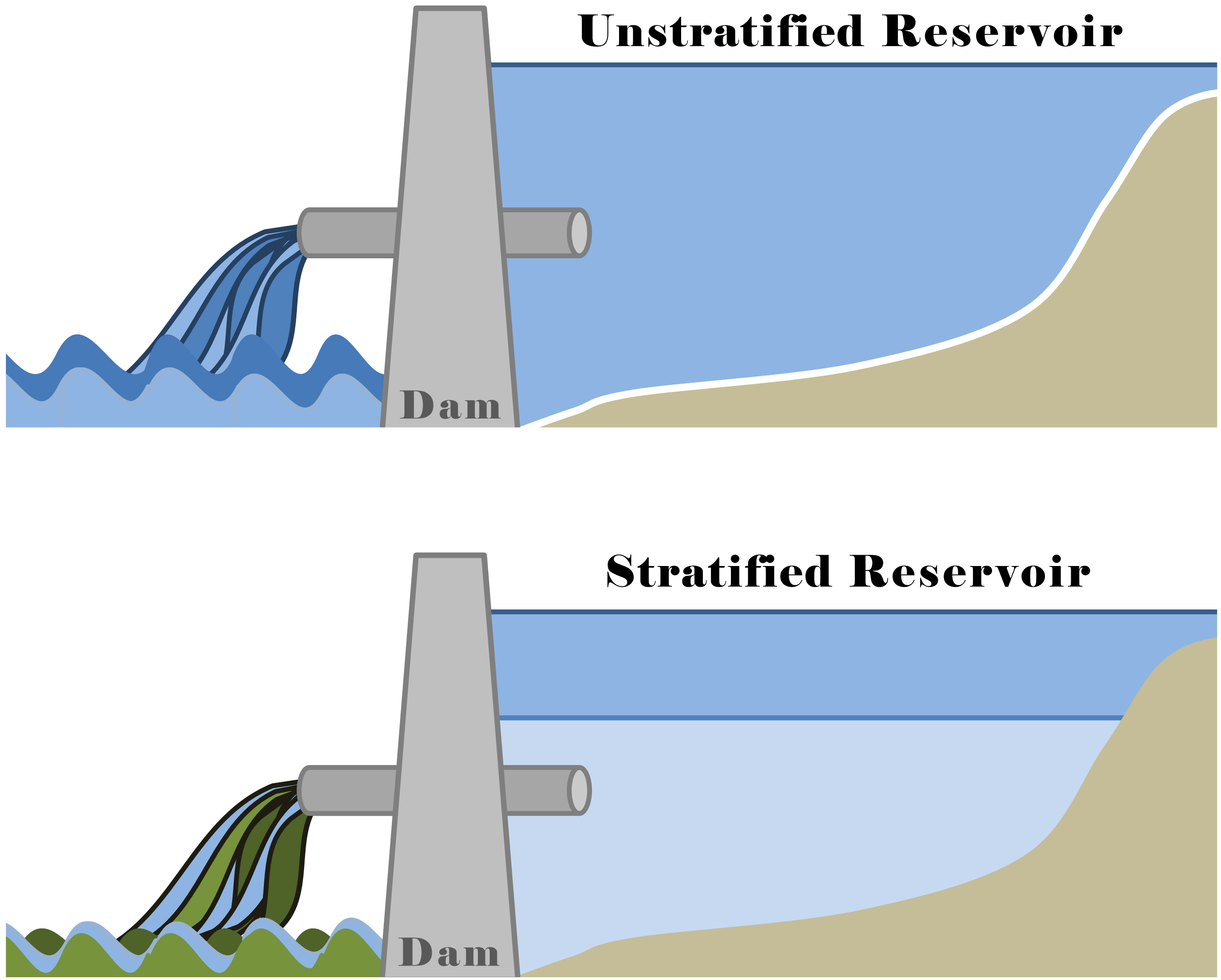


Sand Boil

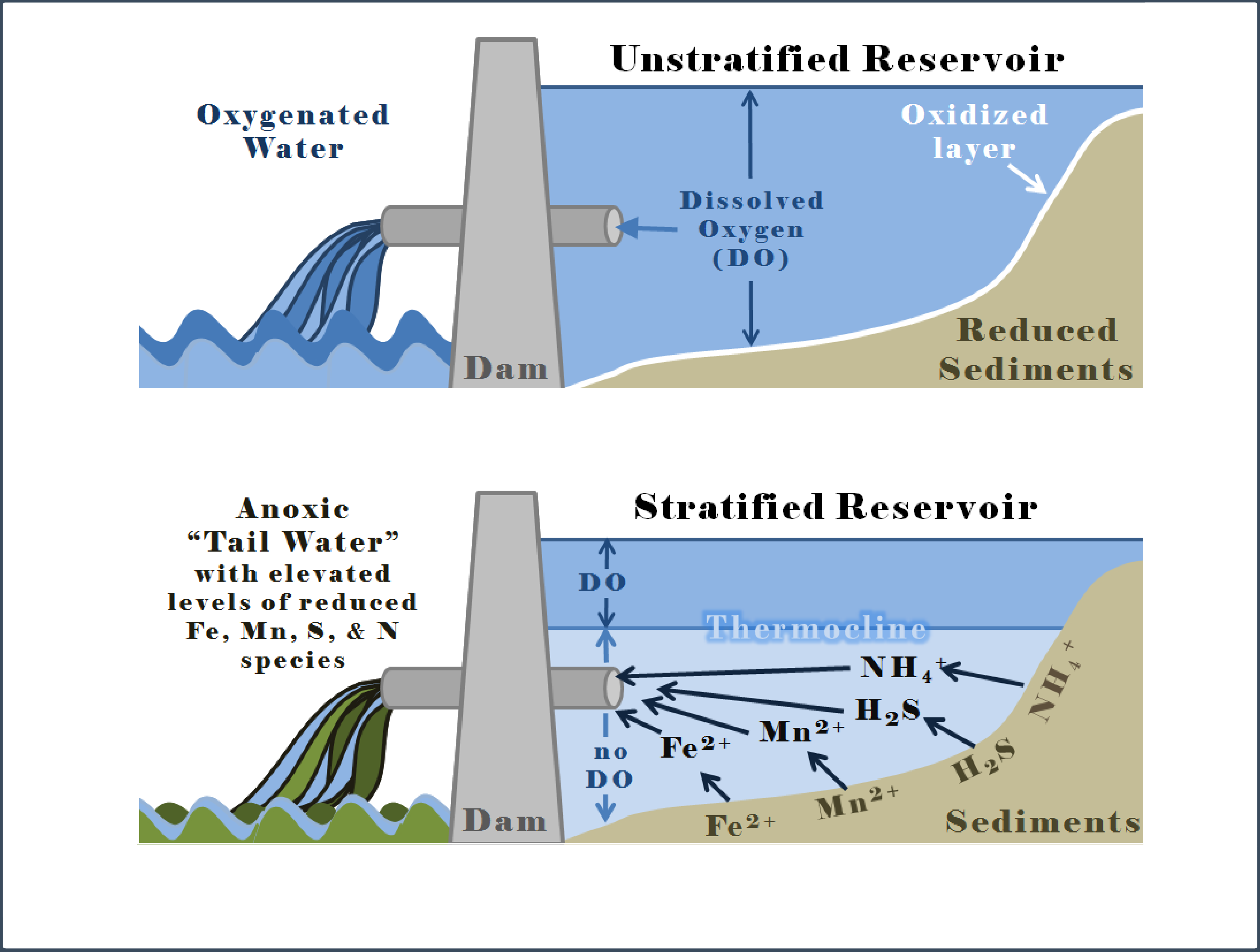
Adapted from the following Diagram:

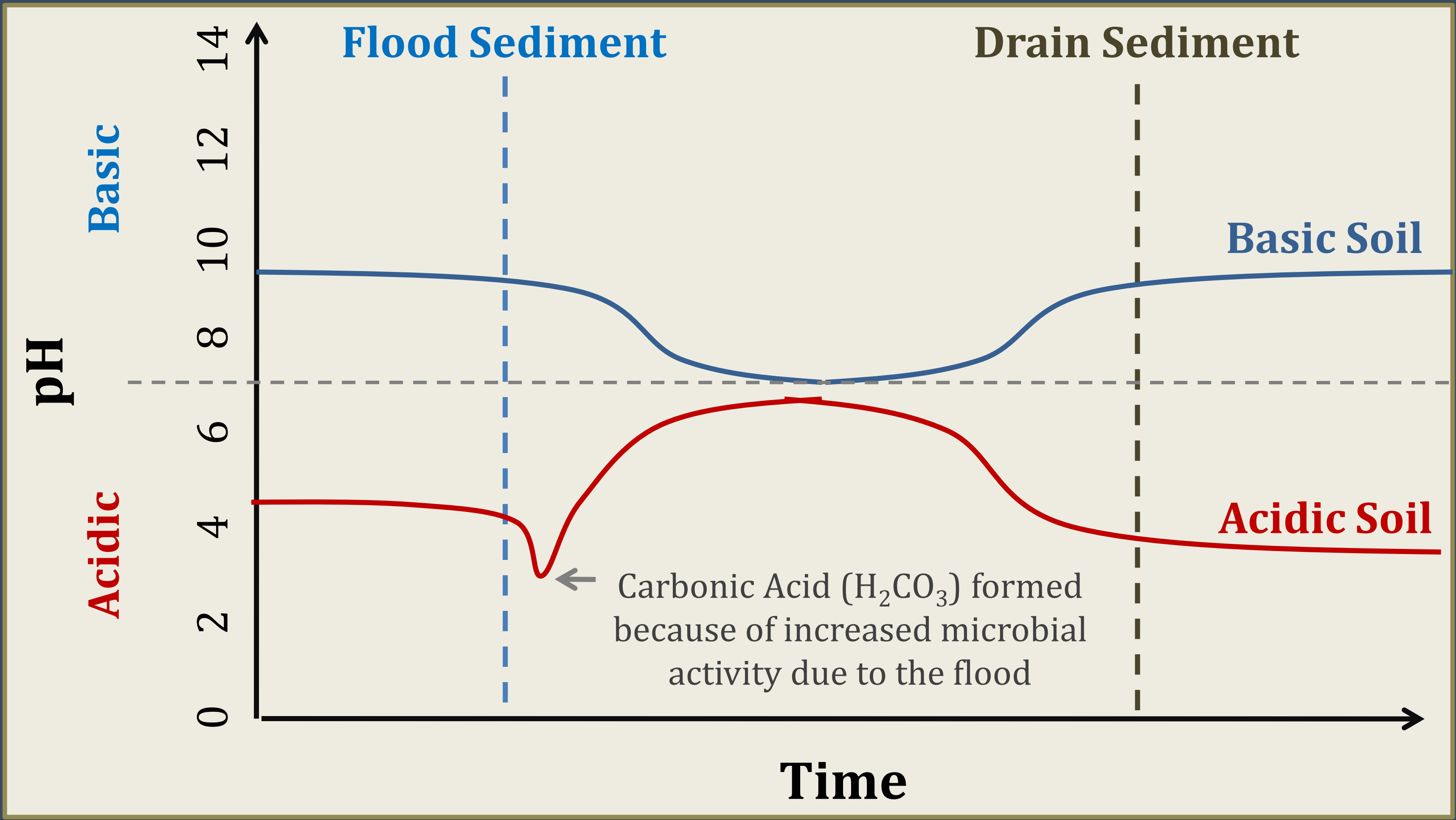
http://www.ew.govt.nz/environmental-information/River-levels-&-rainfall/Flood-event-pages/Stopbank/

Dams (Unstratified vs Stratified Reservoirs) – blank

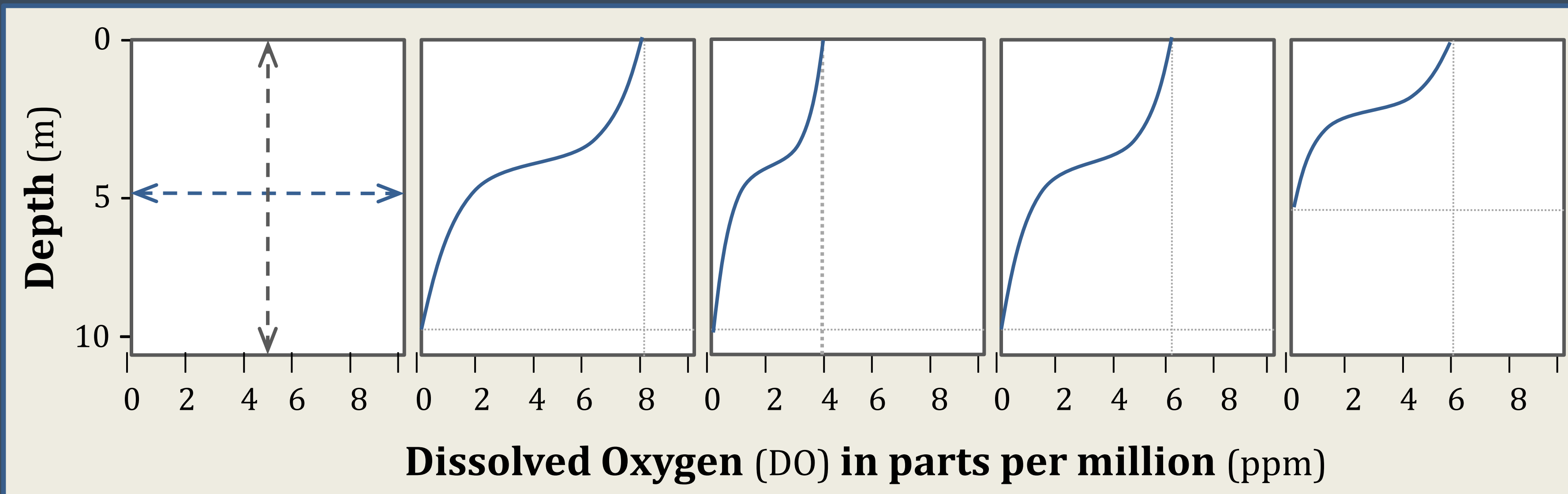


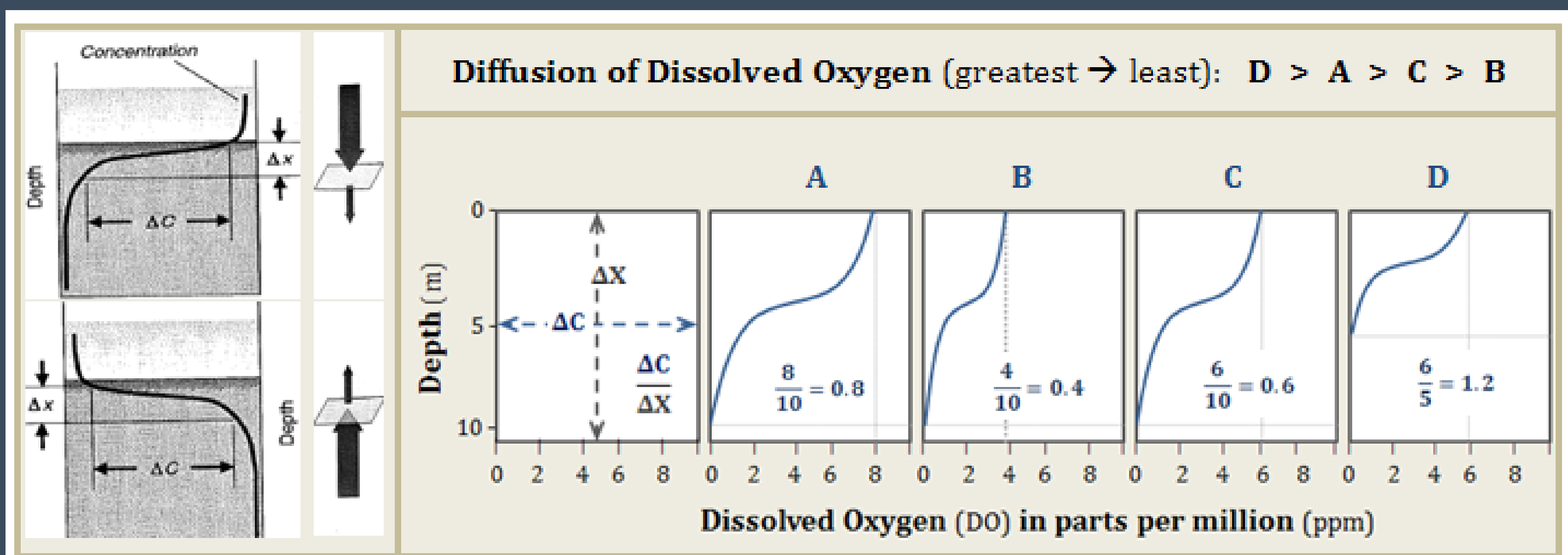
Dams (Unstratified vs Stratified Reservoirs)



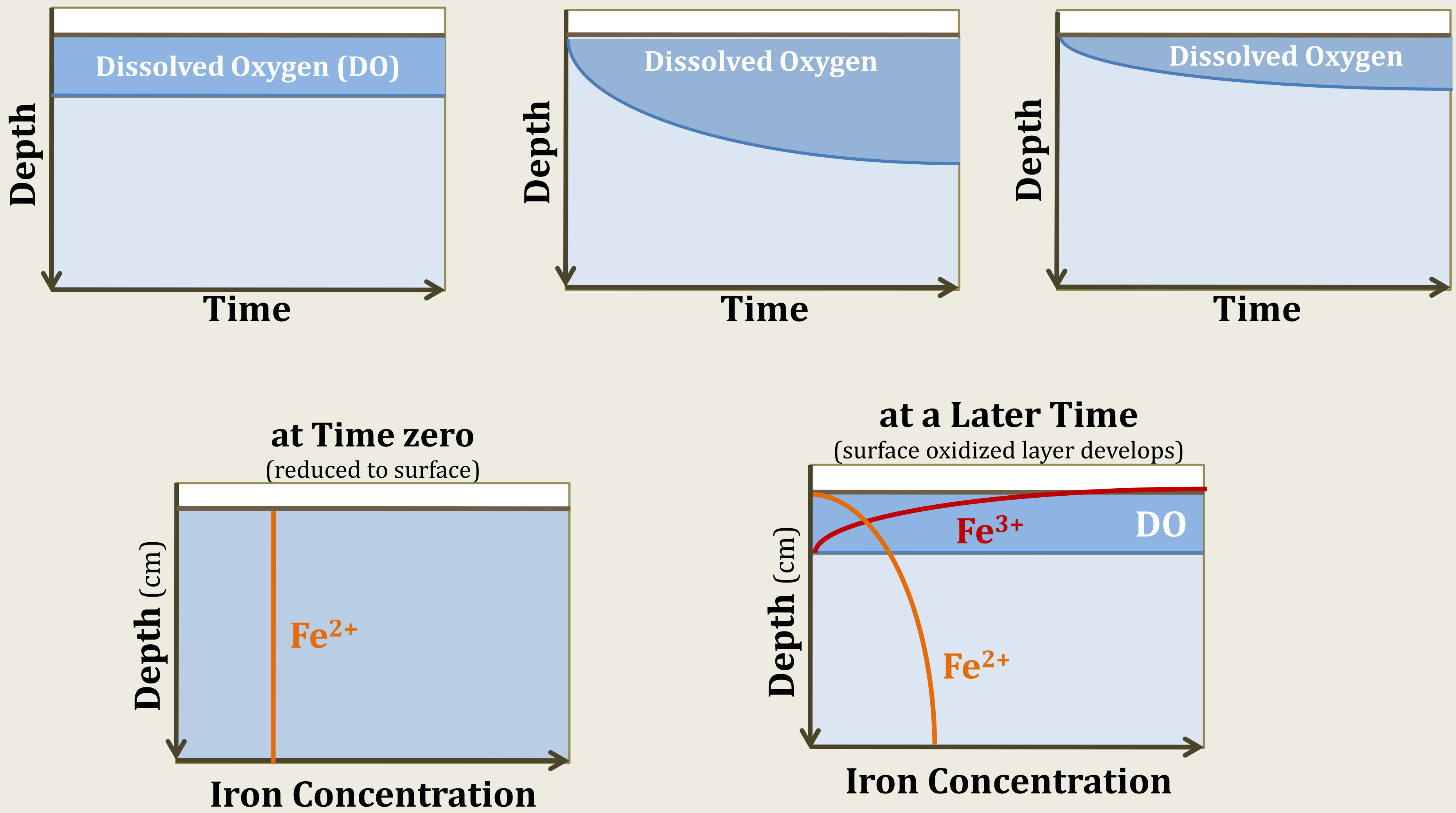


Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*





Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*



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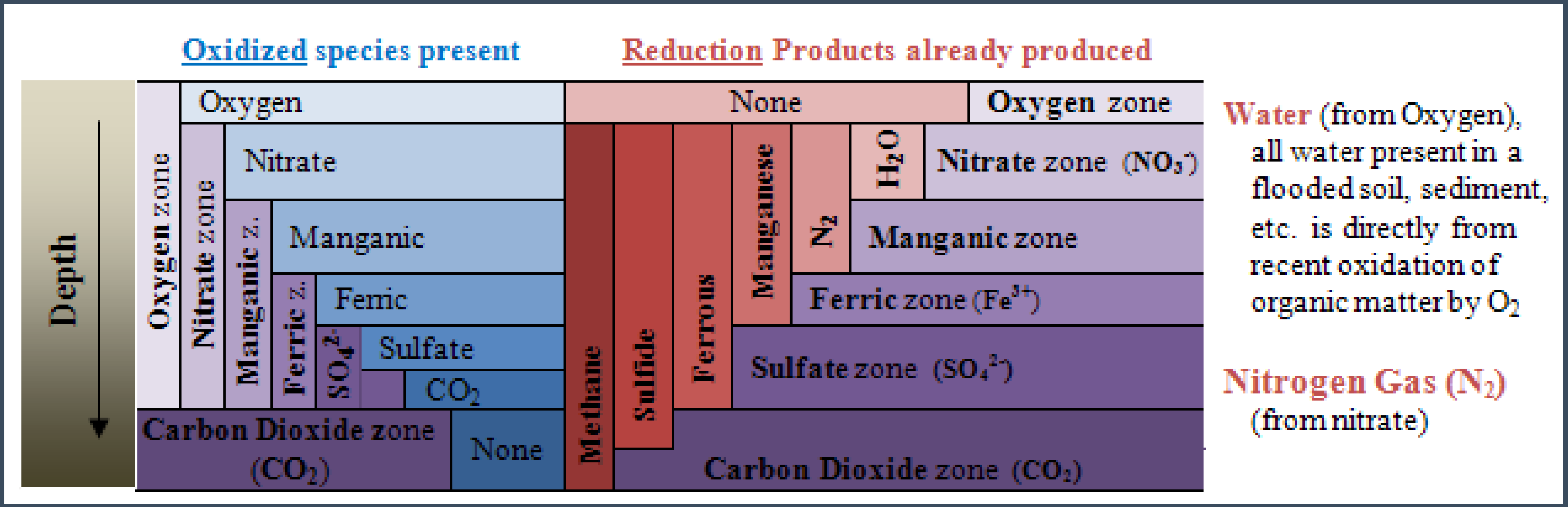
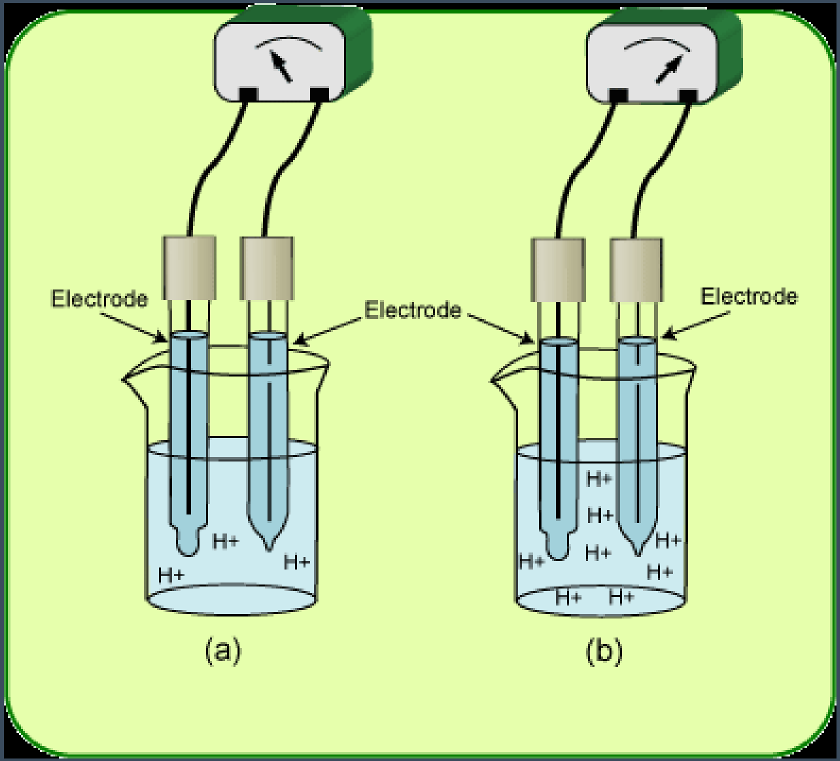


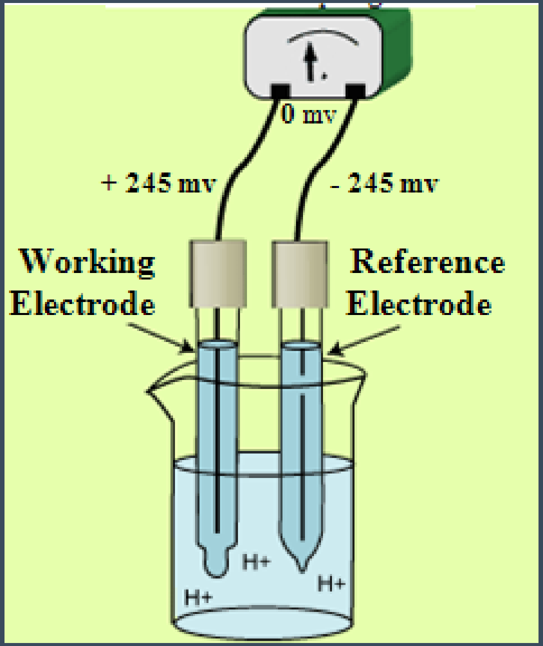
Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Overview of a pH Measuring System

The Original Diagram

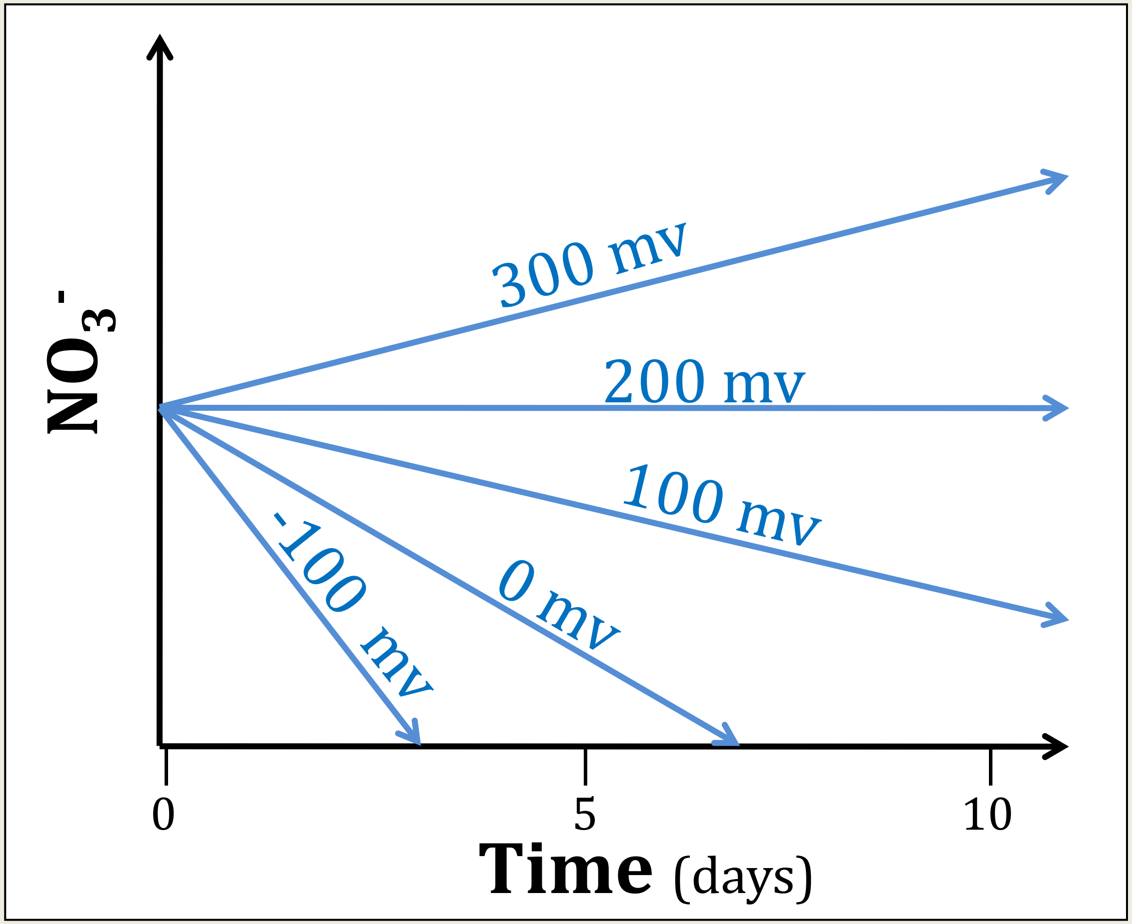


My Adapted Version



"**Figure 1. OVERVIEW OF A pH MEASURING SYSTEM**. The system consists of two electrodes that are immersed in the sample and that are connected to one another through a meter. A. The concentration of hydrogen ions in the solution is relatively low. B. A higher concentration of hydrogen ions leads to a change in the voltage difference between the two electrodes."

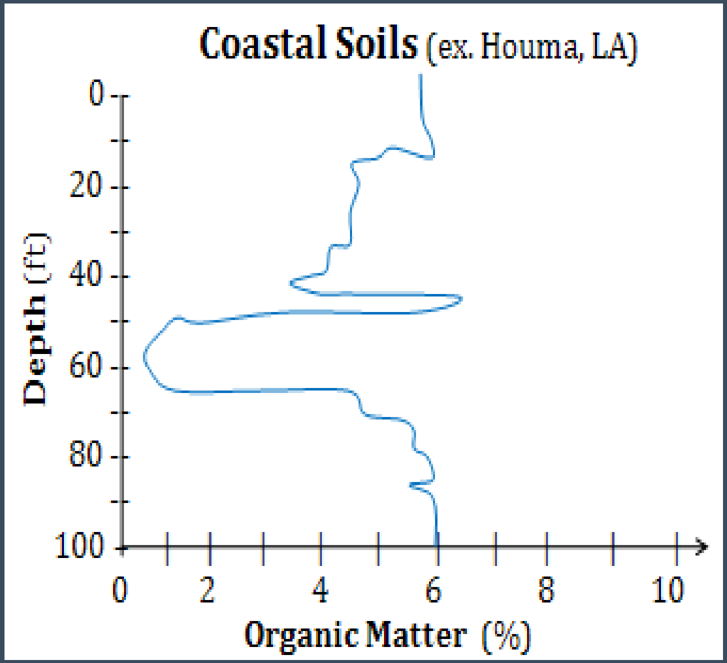
The original diagram is available online at:
http://matcmadison.edu/biotech/resources/methods/labManual/unit_2/exercise_5.htm

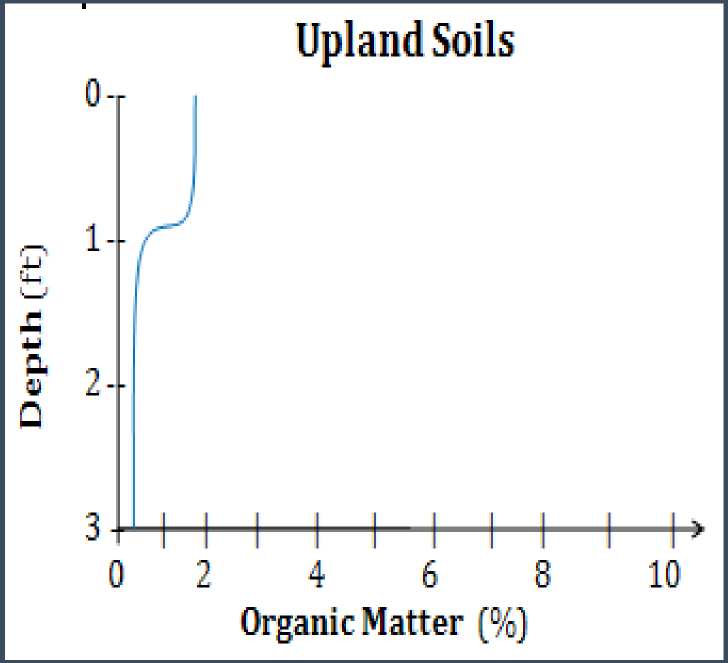


Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Upland vs. Coastal Soil Organic Matter

Sediment Depth Profiles





Adapted from Dr. Gambrell's 2009 course notes for
Biogeochemistry of Wetland Soils & Sediments (OCS 7165)

Grain Size Classification

Fraction	Diameter (mm)	# Particles / Gram	Surface Area / Gram or (cm^2)
Very Course Sand	2.0 – 1.0	90	11
Course Sand	1.0 – 0.5	720	23
Medium Sand	0.5 – 0.25	5,700	45
Fine Sand	0.25 – 0.10	46,000	91
Very Fine Sand	0.10 – 0.05	722,000	227
Silt	0.05 – 0.002	5,776,000	454
Clay	< 0.002	90,260,853,000	8,000,000
Fine Clay	< 0.2 microns	?	?

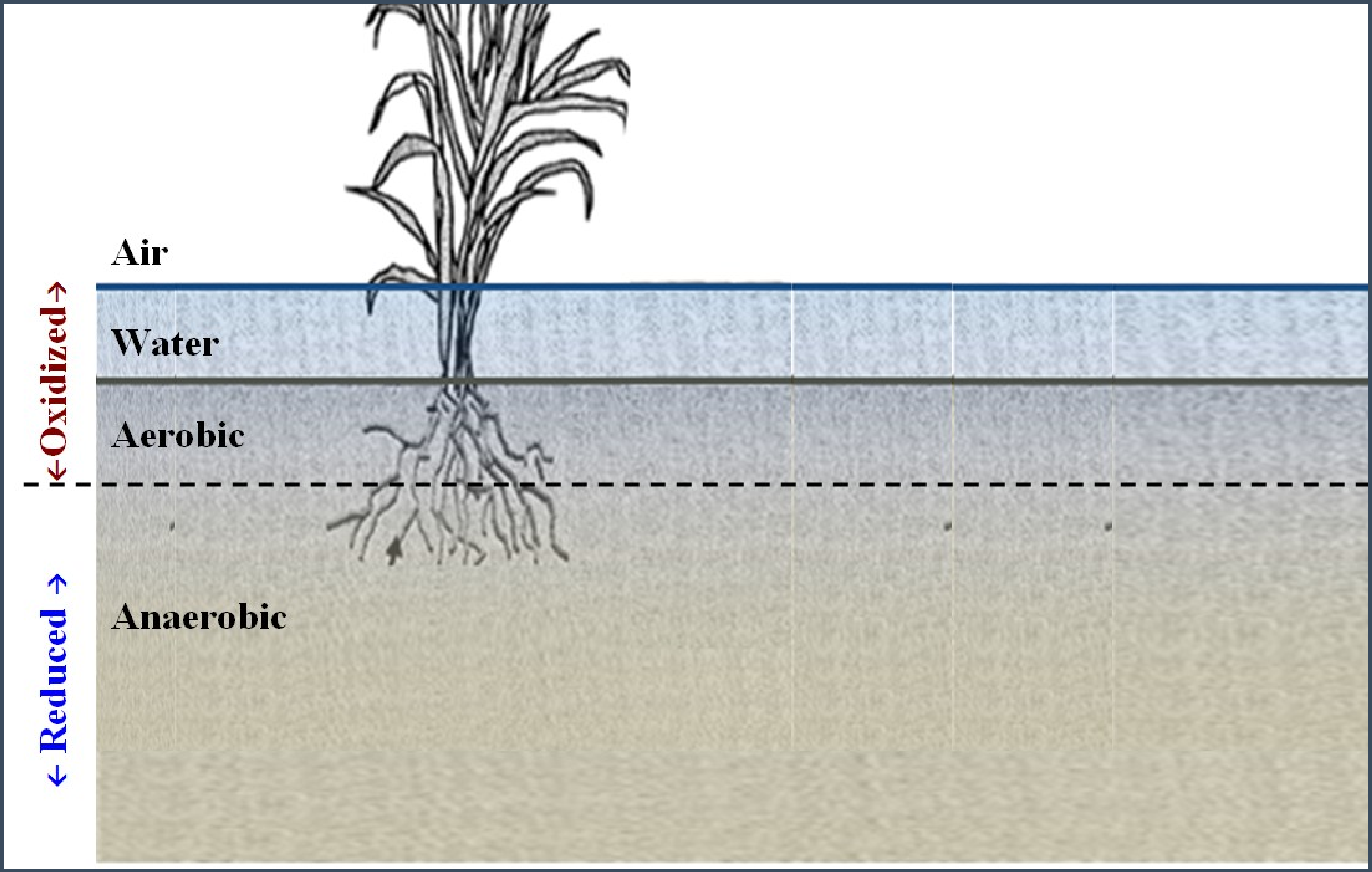
Adapted from Dr. Gambrell's 2009 course notes for
Biogeochemistry of Wetland Soils & Sediments (OCS 7165)

Productive Surface Soils (Microbial Population)

Organism	# organisms / gram of soil
Aerobic bacteria	7,800,000
Anaerobic bacteria	1,950,000
Actinomycetes	2,080,000
Fungi	119,000
algae	25,000
(Table 1, Alexander)	

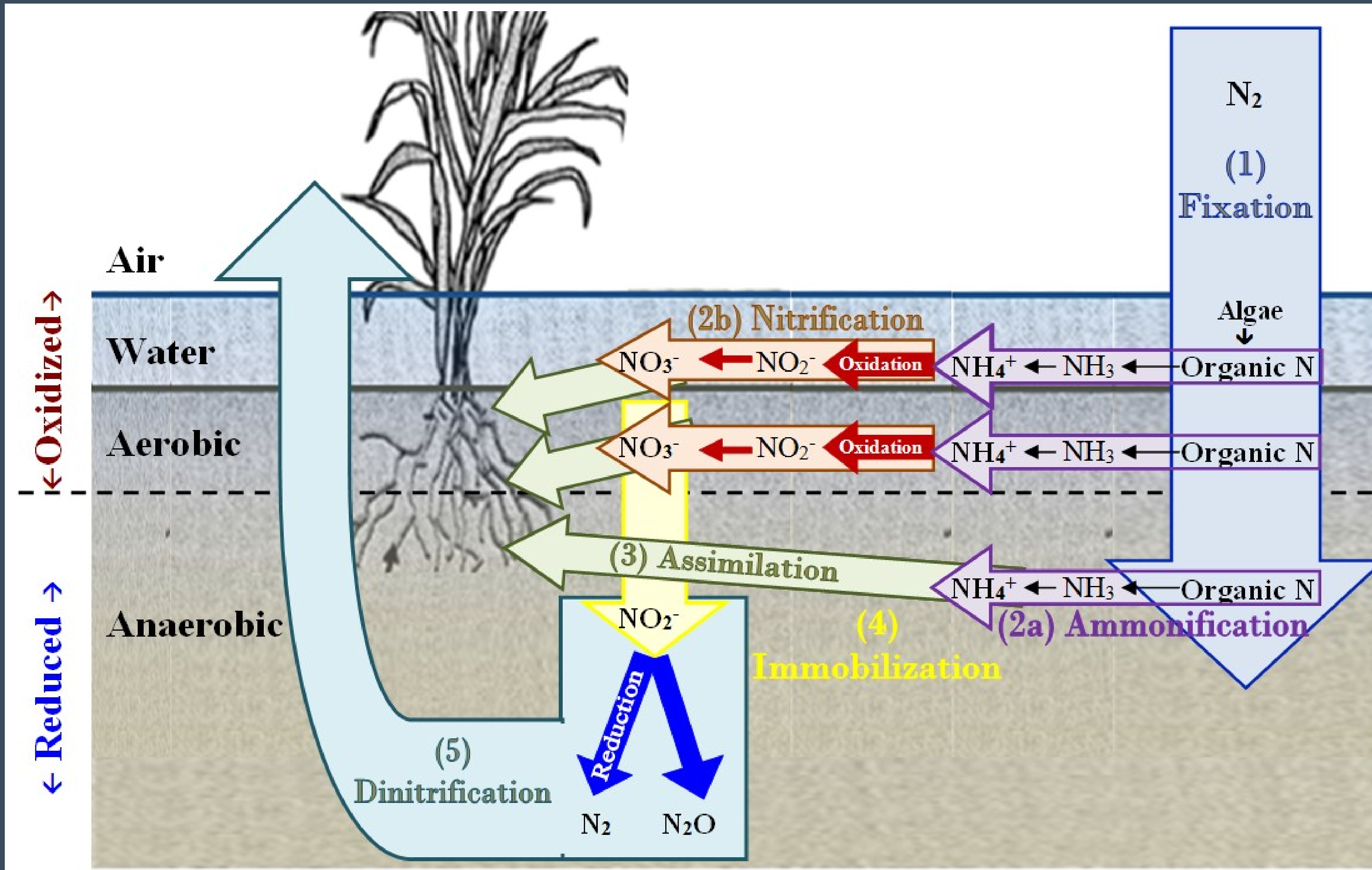
Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Wetland Chemical Cycle – Blank Diagram



Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Wetland Chemical Cycle – the **Nitrogen** Cycle



Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Valance States

Valence States of ...					
Copper (Cu)		**Sodium (Na)**		**Aluminum (Al)**	
Cu^0	- in its metallic state & as a **solid**	**Na^0**	- in its metallic state & as a **liquid**	**Al^0**	- in its metallic state
Cu^{2+}	- dissolved in water as a free cation - bound to clay mineral - bound to sediment organic matter - bound to the following other elements as a compound in its divalent state (2+) └ Copper Sulfate ($CuSO_4$) └ Copper Sulfide (CuS) └ Copper Chloride ($CuCl_2$) └ Copper Carbonate ($CuCo_3$)	**Na^{1+}** or **Na^+**	- dissolved in water - absorbed to clay minerals by cation exchange reactions (complexed with organic matter) - bound to another mineral forming a compound bound to sediment organic matter └ Sodium Chloride (NaCl or Na^+Cl^-)	**Al^{3+}**	- as compounds in soils, sediments, plants, or water, etc. is either free or bound - as compounds of trivalent └ Aluminum Chloride ($AlCl_3$)

Multiple Valence States of Common Elements in the Atmosphere, Soils, Sediments, Water, & Living Organisms		
Nitrogen	**N**	common valence states range from **-3** in **NH_3**, to **+5** as in **NO_3^-**, & several other states forming compounds
Carbon	**C**	common valence states range from **+2** to **+4**
Sulfur	**S**	common valence states range from **+6** in **SO_4^{2-}**, to **-2** as in **Sulfide** (**S^{2-}**), & several other states in between
Iron	**Fe**	valence states in natural systems is usually **+2** as in **Fe^{2+}**, or **+3** as in **Fe^{3+}**
Manganese	**Mn**	valence states in natural systems is usually **+2** as in **Mn^{2+}**, or **+4** as in **Mn^{4+}**
Chromium	**Cr**	valence states in natural systems is usually **+3** as in **Cr^{3+}**, or **+6** as in **Cr^{6+}** such as **Chromate**, **$Cr_2O_7^{2-}$**
Arsenic	**As**	valence states in natural systems is usually **+3** as in **Arsenite** (**As^{3+}**), or **+5** as in **Arsenate** (**As^{5+}**), & others

Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Iron (Fe) & Manganese (Mn) Chemistry

Amount of soluble Fe & Mn that can be generated in some sediments under anaerobic or reducing conditions under a range of pH levels:

The Effect of Controlled pH & Redox Potential on Water Soluble Levels* of **Iron** in a Lab Microcosm Study of a Barataria Bay (LA) Sediment Slurry

Oxidation-Reduction Conditions				
pH	**Strongly Reduced**	**Weakly Reduced**	**Borderline**	**Well Oxidized**
	---------------------------------Fe ppm -------------------------------			
5.0	240.0	110.0	1.0	1.5
6.5	21.0	23.0	0.8	0.7
8.0	0.4	0.2	0.3	0.2

* The original data reported concentrations in terms of micrograms of soluble elements per g of oven dry sediment solid equivalent. With an approximate 8 to 1 ratio of water to oven dry sediment solids in this study, the report values have been divided by 8 to approximate the concentrations on a micrograms per milliliter basis (ppm).

The Effect of Controlled pH & Redox Potential on Water Soluble Levels* of **Manganese** in a Lab Microcosm Study of a Barataria Bay (LA) Sediment Slurry

Oxidation-Reduction Conditions				
pH	**Strongly Reduced**	**Weakly Reduced**	**Borderline**	**Well Oxidized**
	-------------------------------Mn ppm -------------------------------			
5.0	13.50	10.90	14.25	13.75
6.5	8.63	10.38	7.88	0.74
8.0	1.60	0.20	n.d.	n.d.

* The original data reported concentrations in terms of micrograms of soluble elements per g of oven dry sediment solid equivalent. With an approximate 8 to 1 ratio of water to oven dry sediment solids in this study, the report values have been divided by 8 to approximate the concentrations on a micrograms per milliliter basis (ppm).

(from a Gambrell et al., report on redox chemistry of trace & toxic metals in dredged materials)

Adapted from Dr. Gambrell's 2009 course notes for *Biogeochemistry of Wetland Soils & Sediments (OCS 7165)*

Radial Belt Transect

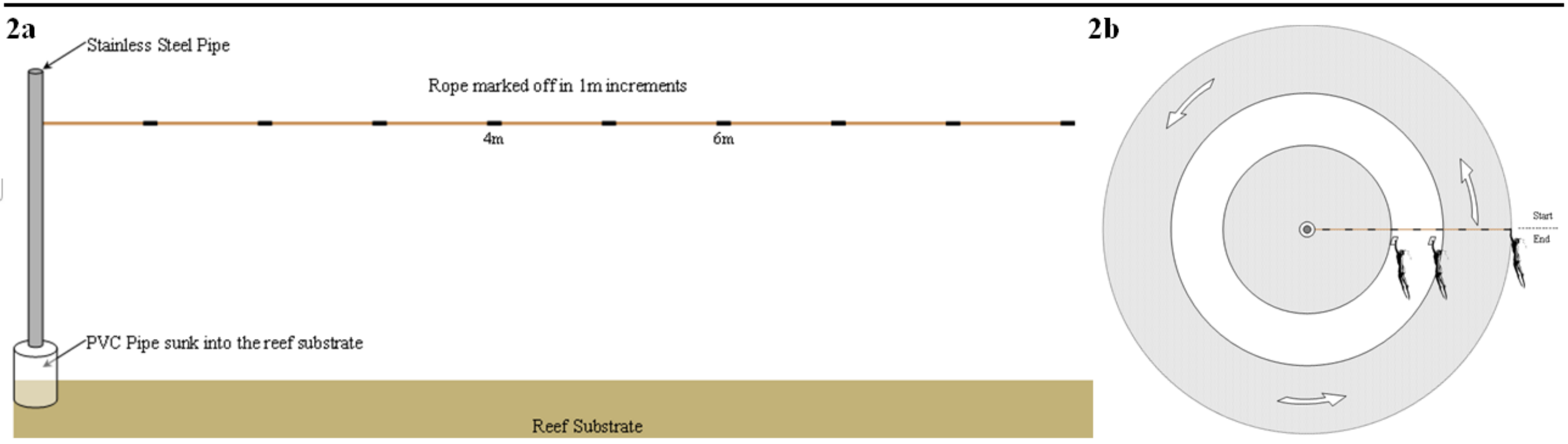
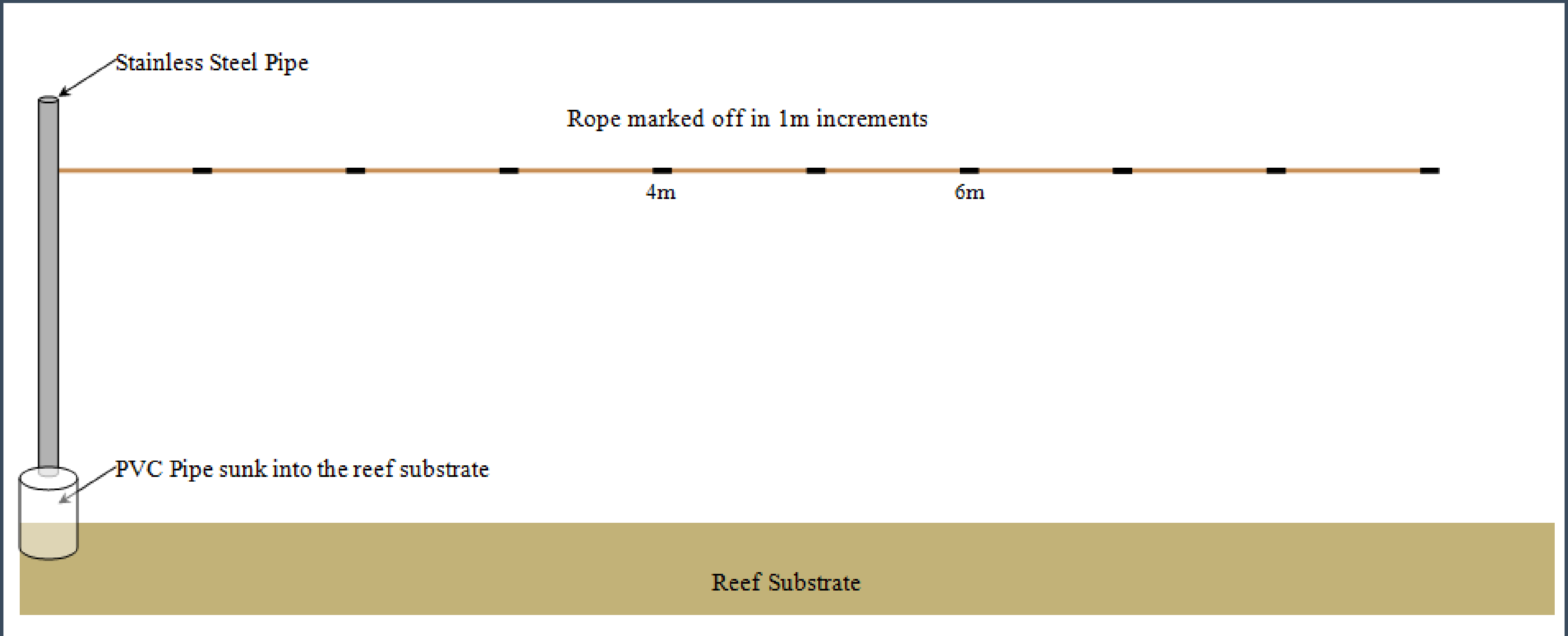


Figure 2. (a) Side-view of the Radial Belt Transect. **(b)** Arial view of the radial belt transect, the "line tender" is shown holding the transect rope on the far right, the two samplers and the sampling area of shown within the white region of the circle. The transect was swum in a counter-clockwise direction, depicted by the white arrows.

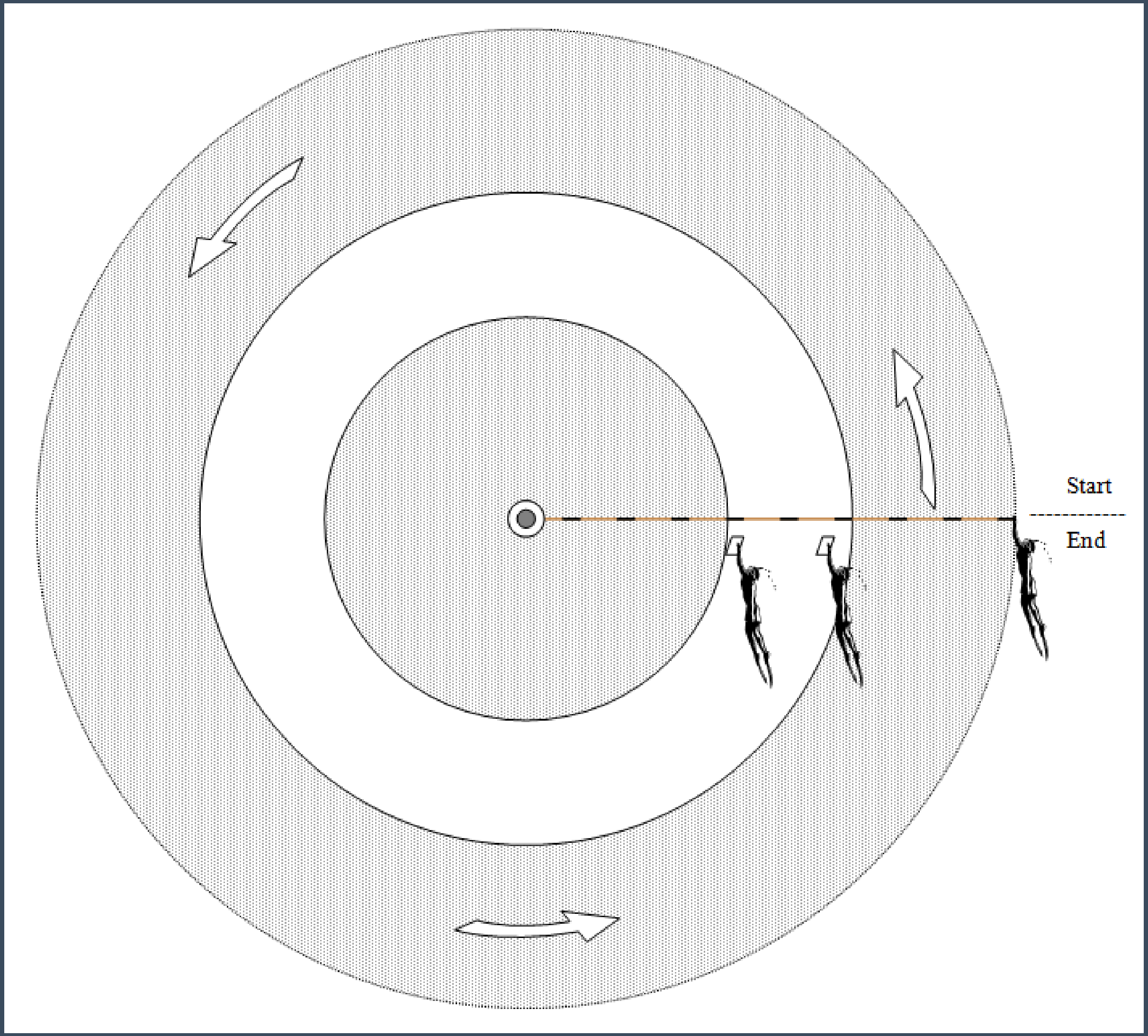
an original figure created by Jennifer Lentz

Radial Belt Transect – close-up of Side View



an original figure created by Jennifer Lentz

Radial Belt Transect – close-up of Arial View



an original figure created by Jennifer Lentz

Microbial Studies of Coral Disease

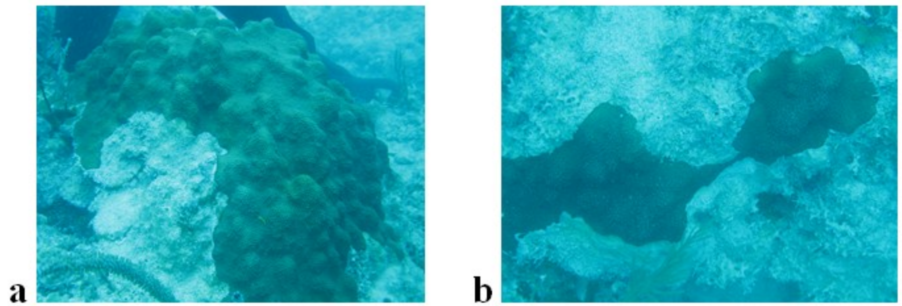


Figure 2. (a) Apparently Healthy colony of *M. faveolata* prior to sampling. **(b)** Healthy portion of the Diseased colony of *M. faveolata* prior to sampling.

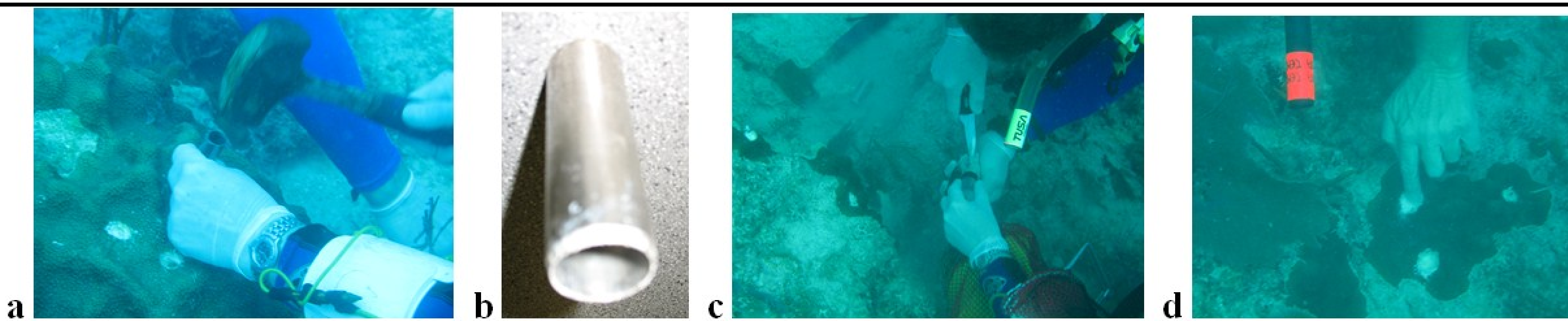


Figure 4. **(a)** Hammering the tube into the coral; **(b)** the 1.7cm diameter, 3 inch long stainless steel tube used to core into the corals; **(c)** place the coral sample into a sterol, screw-caped, polypropylene tube; **(d)** sealing the wholes with clay.

original figures created by Jennifer Lentz and using photos taken by Jennifer Lentz

Microbial Studies of Coral Disease

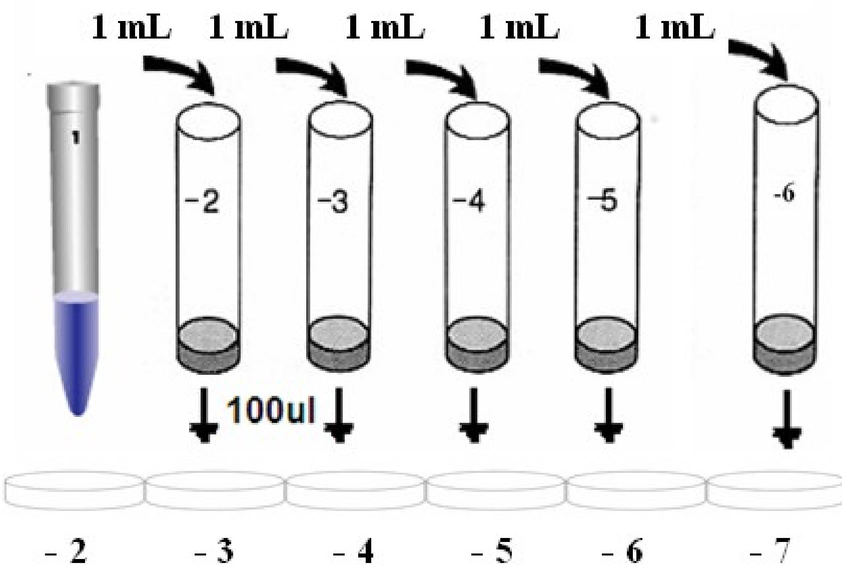


Figure 5. Serial dilution diagram. Diagram adapted from Microbiological study on white band disease from *M. faveolata* by Beatriz Santamaria.

Figure 6. Spreading the 0.1 mL dilutions (dilutions -2 through -7) onto the agar plates using a sterilized glass spreader and a spinning wheel.

original figures created by Jennifer Lentz and using a photo taken by Jennifer Lentz

Microbial Studies of Coral Disease

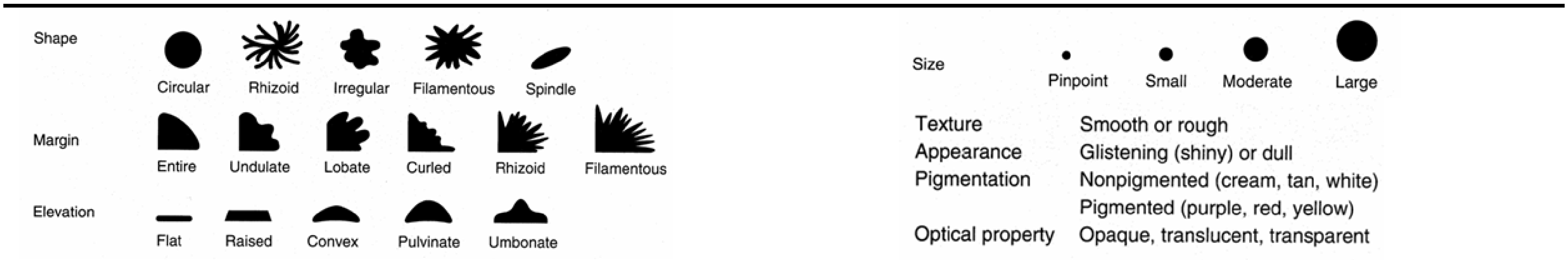


Figure 7. Microbial colony characterization under the compound microscope.

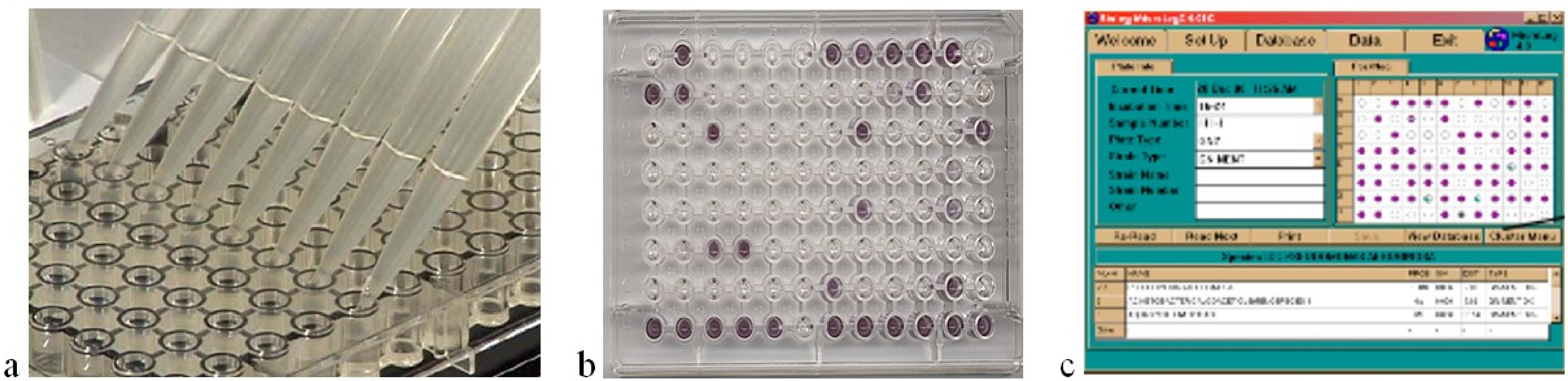


Figure 8. The above pictures (taken from www.biolog.com) show the process of inoculating the MicroArray (a), then reading the results of each plate (b), and last a screen capture of the biolog computer software (c) in which the microarray results are entered and possible bacterial matches are found.

figures created by Jennifer Lentz

Techniques for Quantifying the Amount & Rate of Tissue Loss Caused by Coral Disease

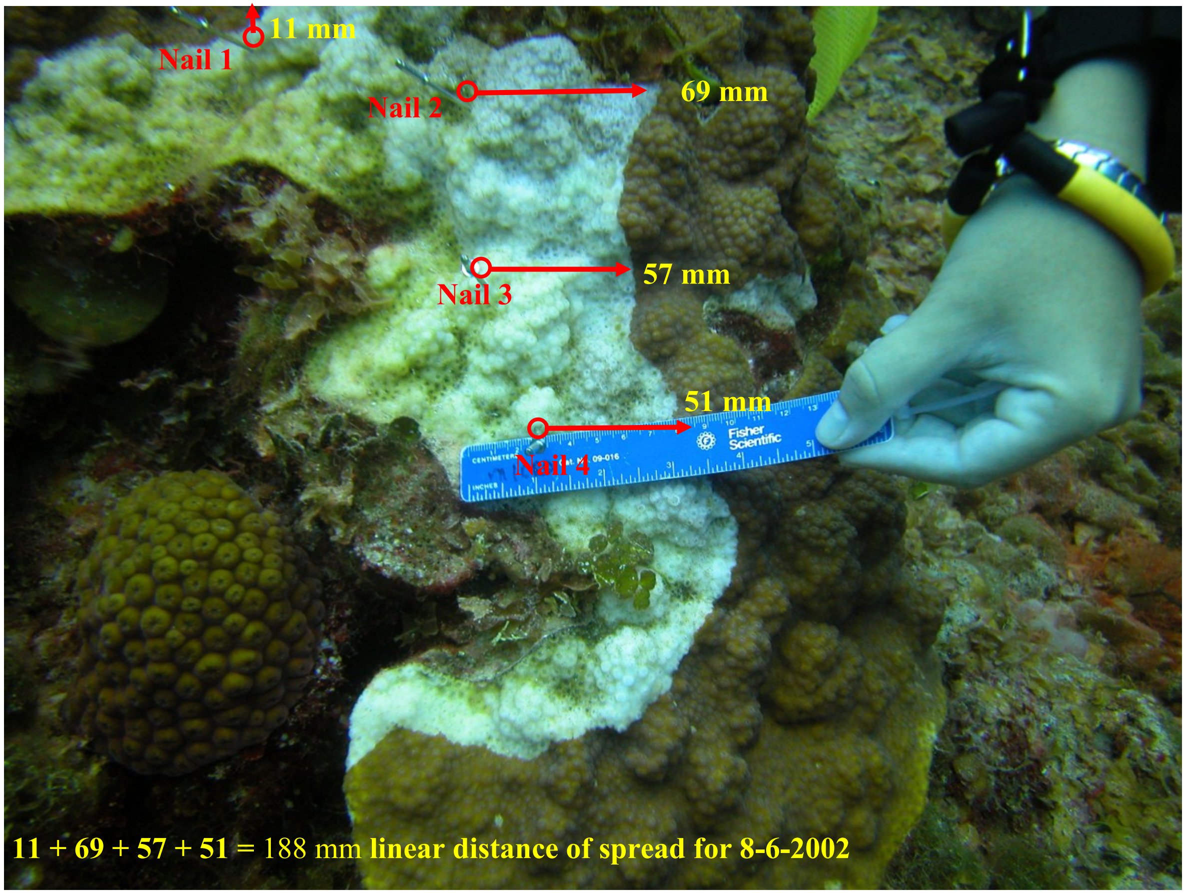


Figure 1. This figure shows the direction from the nail, in which disease spread was measured for each image. The base of the nail is marked with a red circle, and the red arrow indicated both the direction and the distance measured. The image shown in this figure was from 8-6-2002, and the amount of disease spread measured for each nail is shown in yellow. The calculation for distance spread for this image is shown in yellow in the bottom left corner of the figure.

An original figure created by Jennifer Lentz and using a photo taken by Jennifer Lentz

Techniques for Quantifying the Amount & Rate of Tissue Loss Caused by Coral Disease

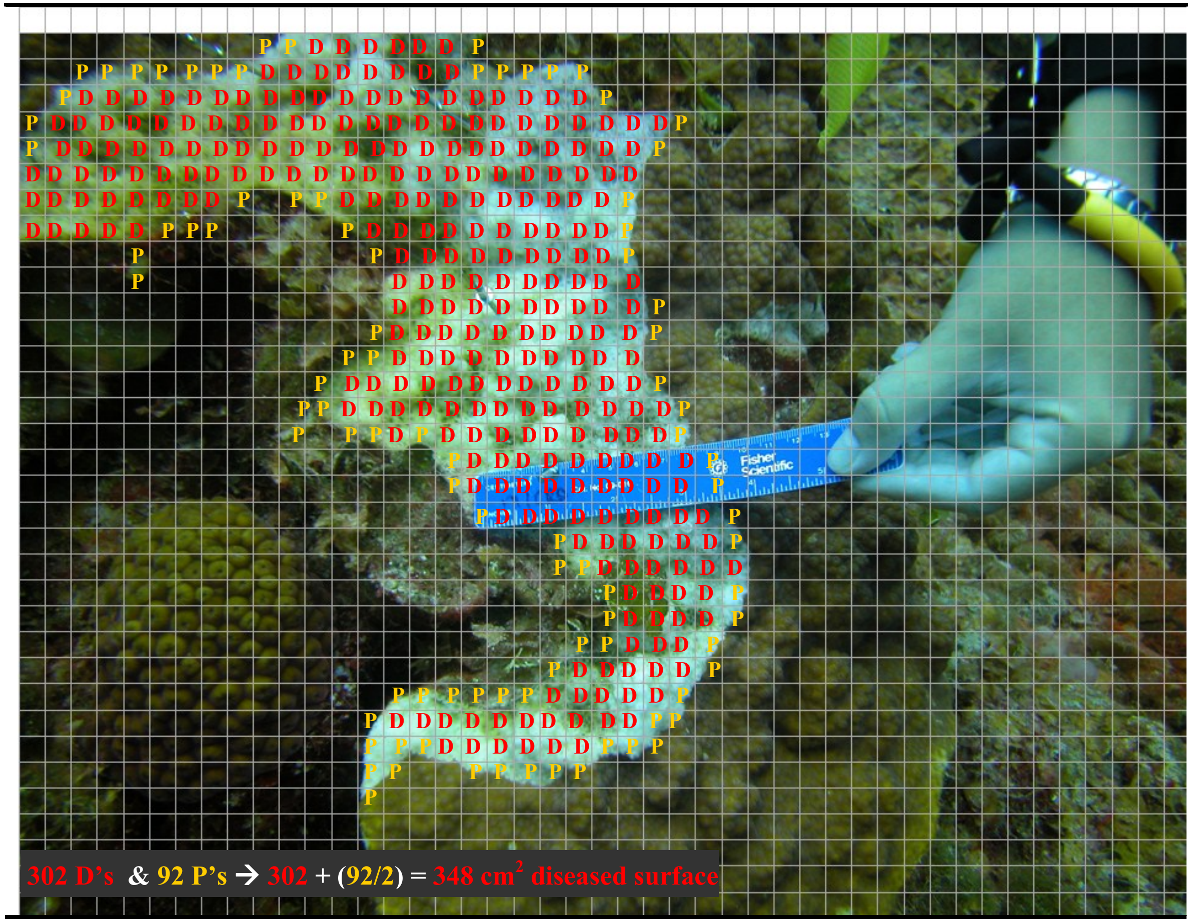


Figure 2. The above figure demonstrates how the grid cell count method was used to estimate the surface area of the disease. The above image was from 8-6-2002, and as the calculation in the lower left corner of the figure shows, the coral had roughly 348 cm^2 of diseased surface.

An original figure created by Jennifer Lentz and using a photo taken by Jennifer Lentz

Techniques for Quantifying the Amount & Rate of Tissue Loss Caused by Coral Disease

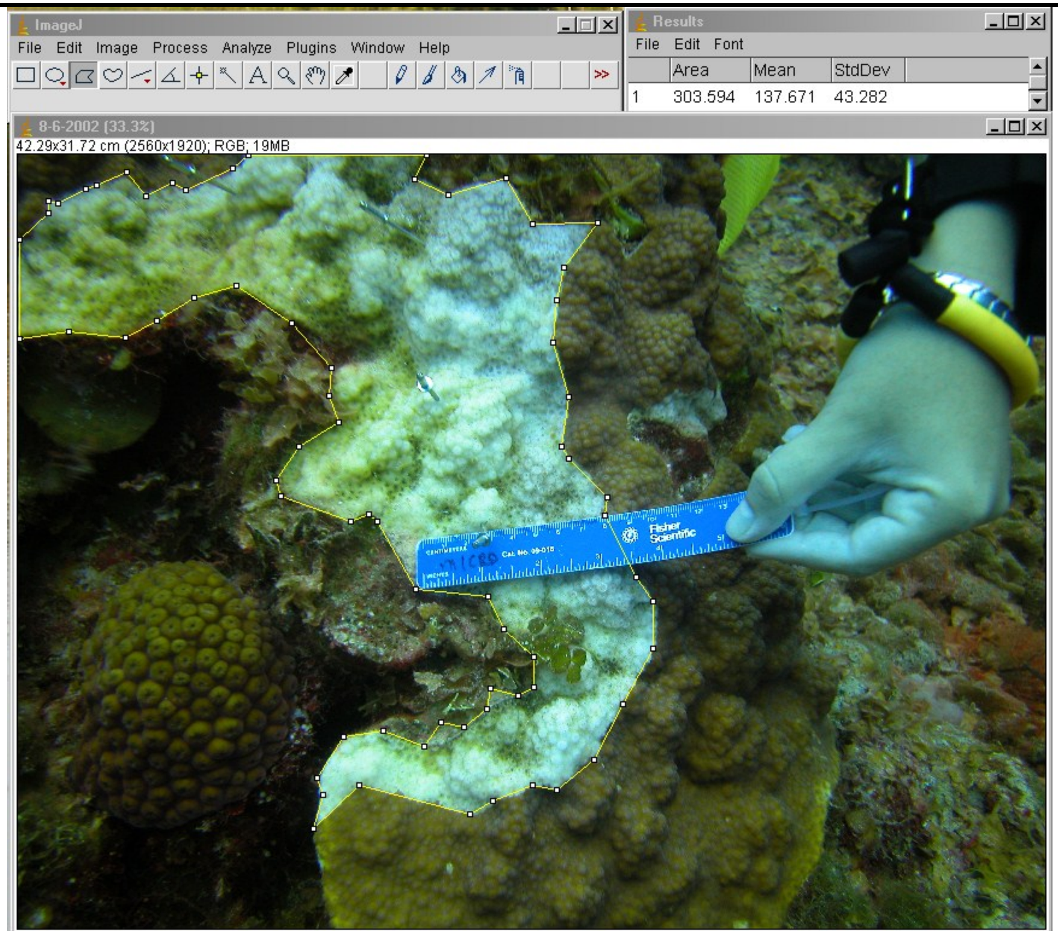
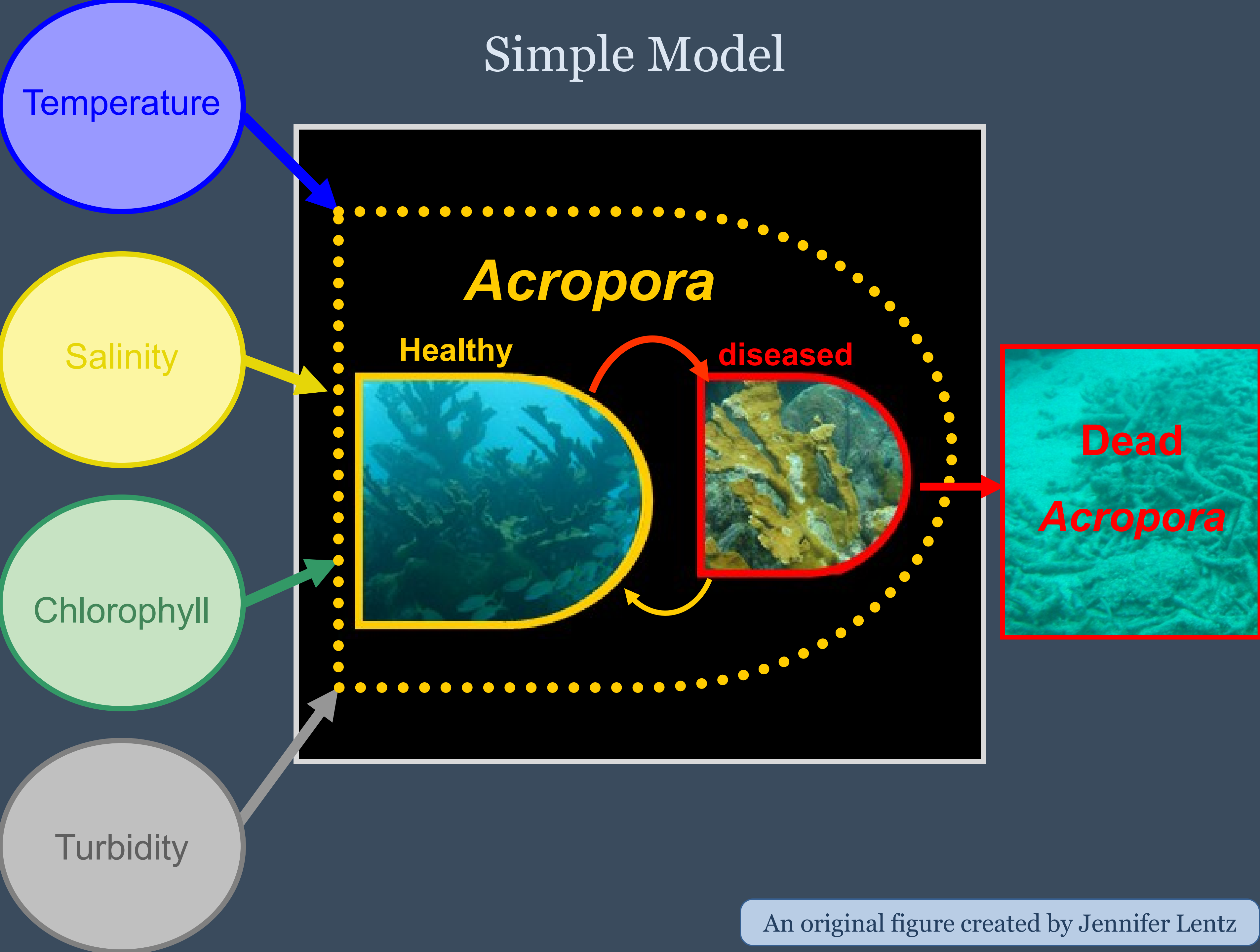


Figure 3. This figure shows how ImageJ software was used to estimate the surface area of the disease in each image. The above image is from 8-6-2002, and had a diseased surface area of 303.59 cm^2.

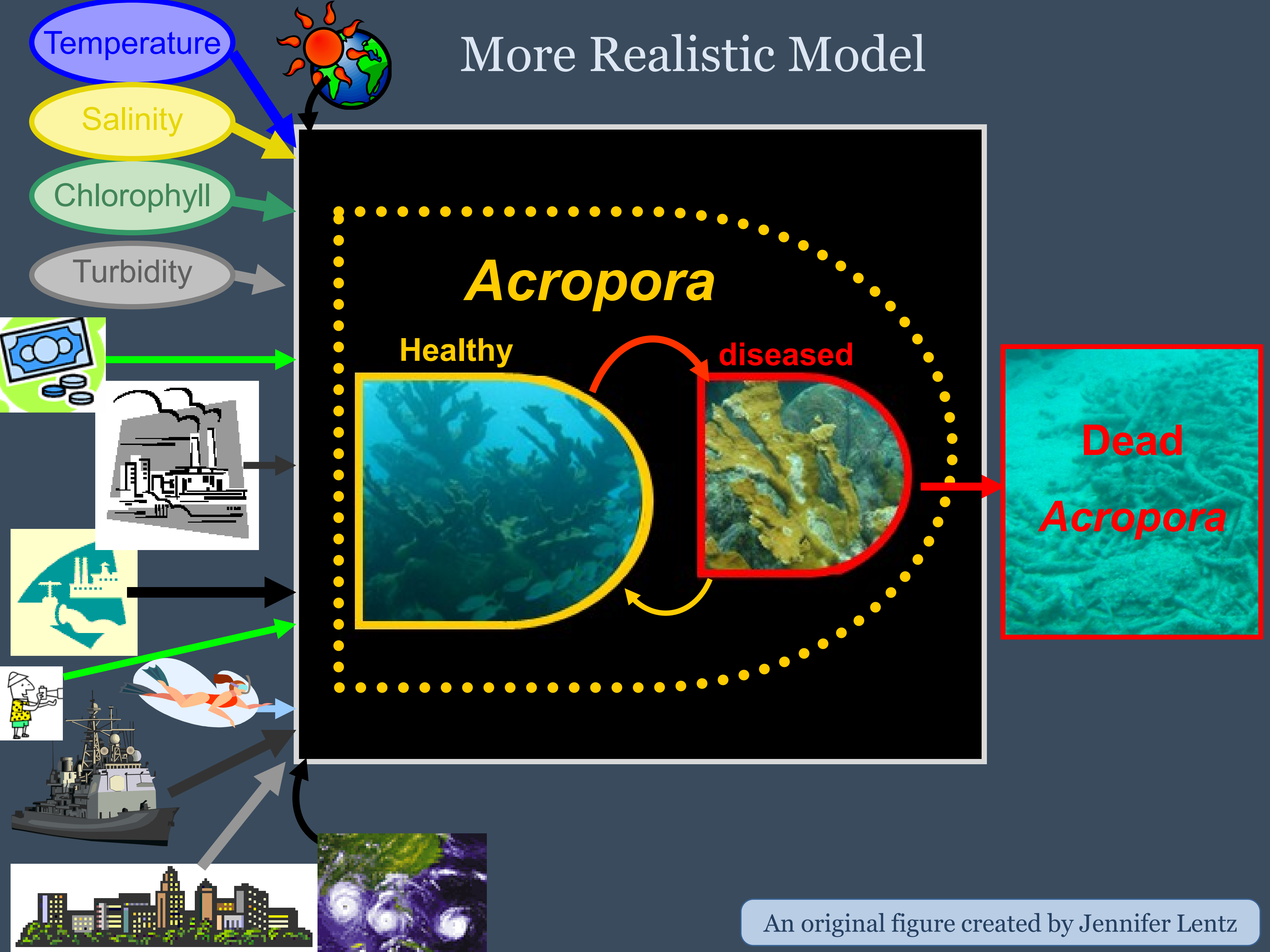
An original figure created by Jennifer Lentz and using a photo taken by Jennifer Lentz

Simple Model



An original figure created by Jennifer Lentz

More Realistic Model



An original figure created by Jennifer Lentz

Black-Band Disease (BBD)

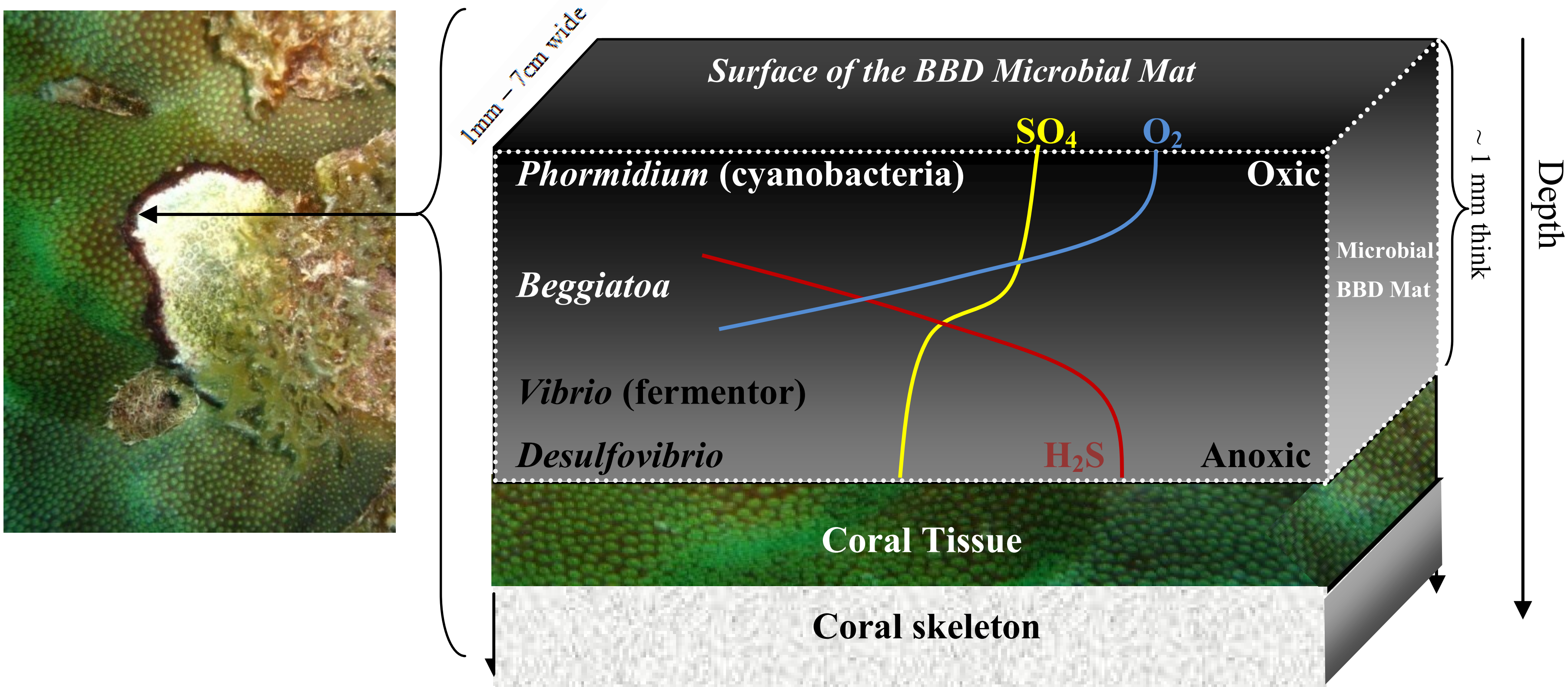
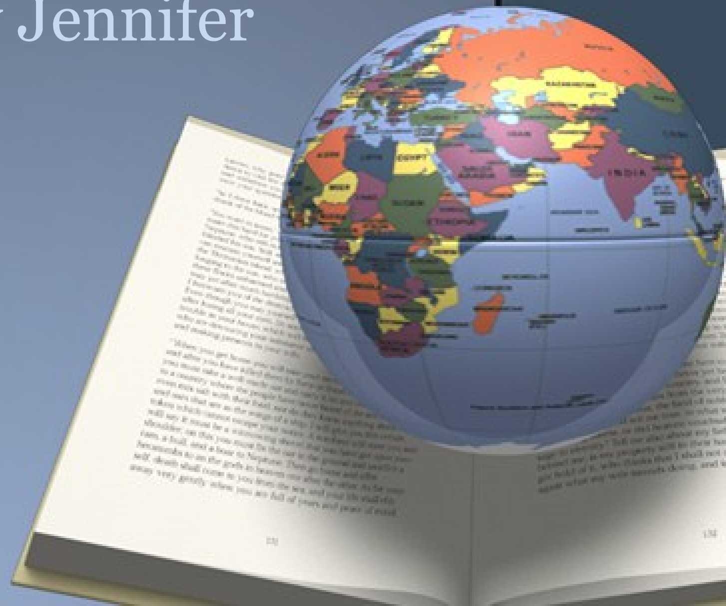


Figure 3. Stylistic cross-section of the dominant microbes of the microbial consortium making up the BBD mat. *Note: this diagram is not done to scale.* (Lentz 2006, unpublished)

original figure created by Jennifer Lentz

Educational Slides from Lectures

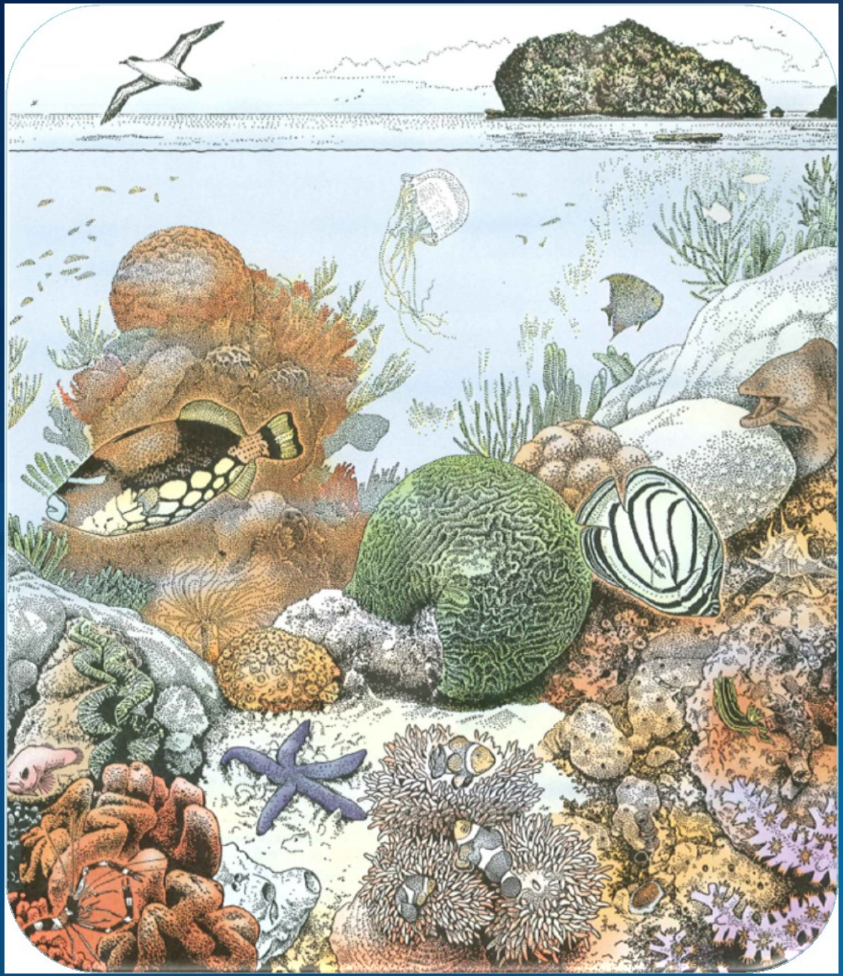
The following slides were created by Jennifer Lentz and were used in lectures given by Jennifer

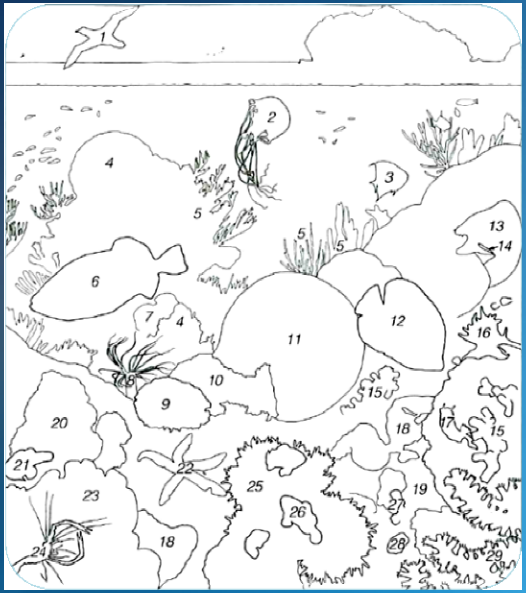


Note: content adapted from other sources is cited

Introduction to Coral Reefs

Coral Reef Ecosystems





Key for coral reef habitat

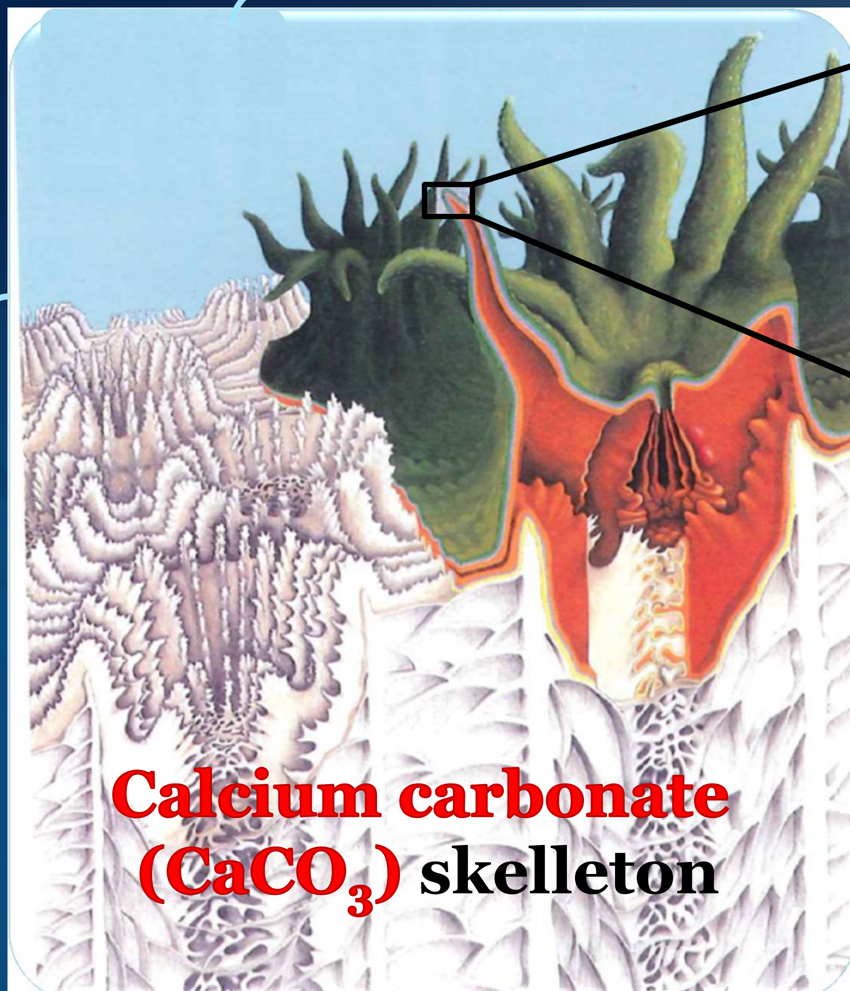
1 black-capped petrel
2 sea nettle
3 angelfish
4 lobed corals
5 sea whips and soft corals
6 triggerfish
7 sea fans
8 tube anemone
9 orange stone coral
10 bryozoans
11 brain coral
12 butterfly fish
13 moray eel
14 cleaner fish
15 tube corals
16 muricid snail
17 nudibranch
18 sponges
19 colonial tunicate
20 giant clam
21 purple pseudochromid fish
22 cobalt sea star
23 soft corals
24 barber pole shrimp
25 sea anemones
26 clown fish
27 worm tubes
28 cowrie
29 sea fan

(Garrison 2007; Fig. 16.2 (a-b); p. 460-461)

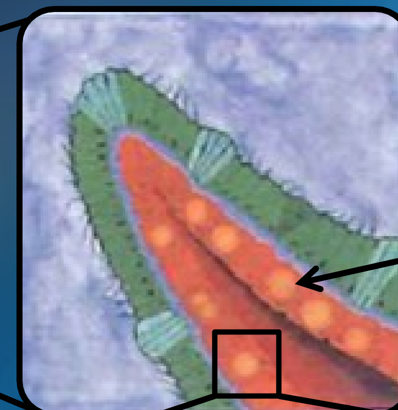
"Coral Reefs"

Biologic Context

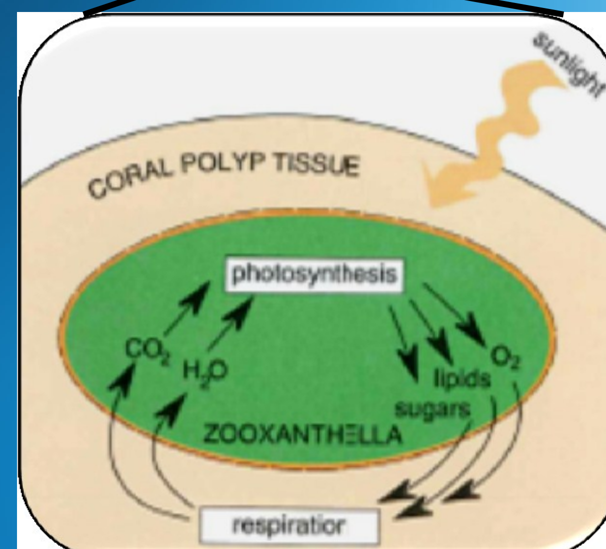
Geologic Context



Calcium carbonate ($CaCO_3$) skelleton



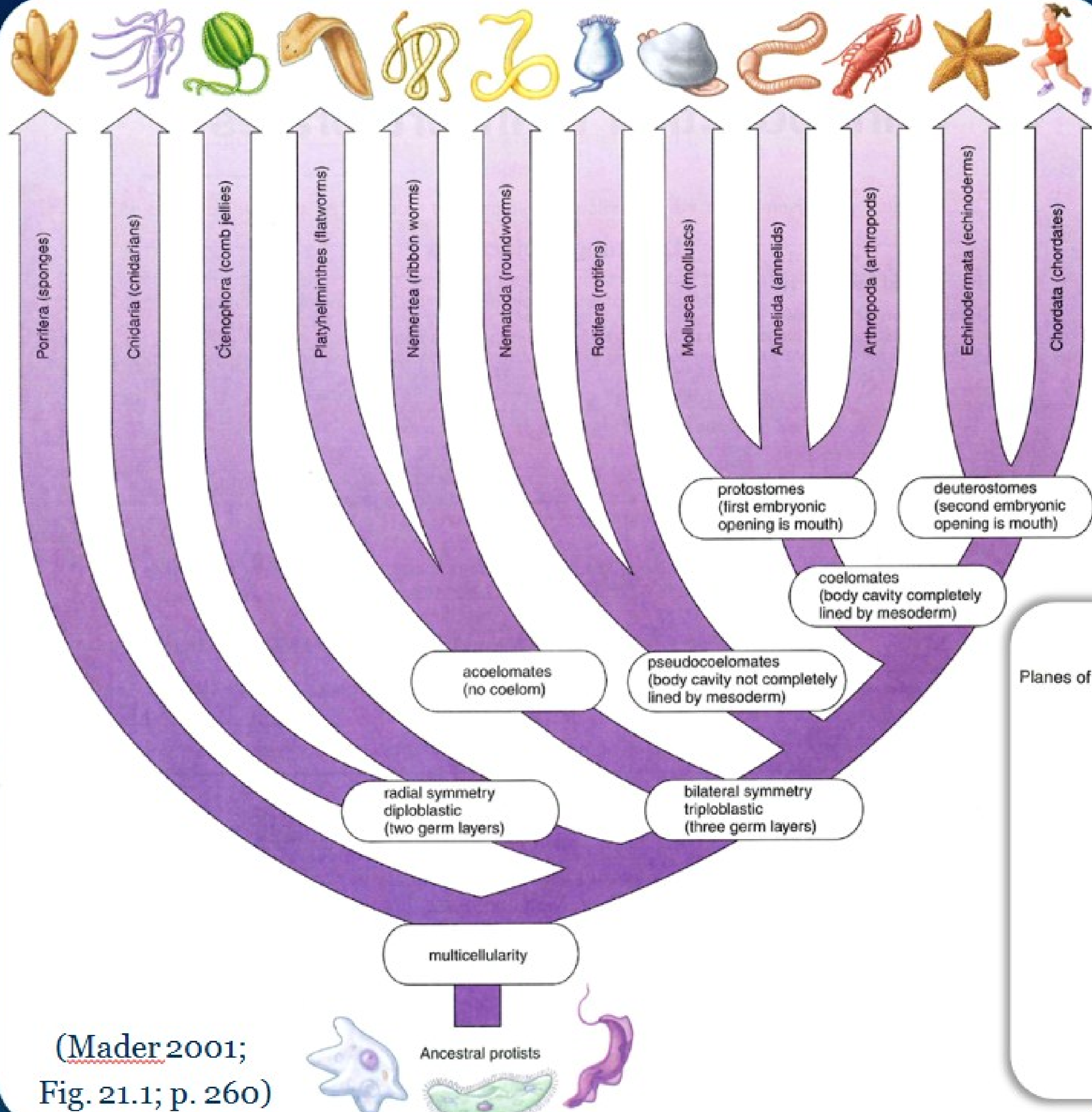
Zooxanthellae (algae)



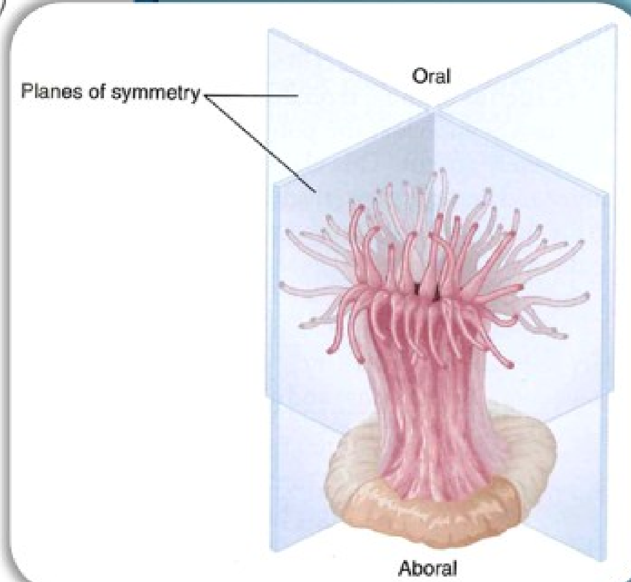
(Adapted from: Murphy 2002, Fig. 2, p. 46; & Sumich & Morrissey 2004; Fig. 9.6; p.258)

Basic Coral Biology

- Kingdom **Animalia**
  - Phylum **Cnidaria**



(Mader 2001; Fig. 21.1; p. 260)



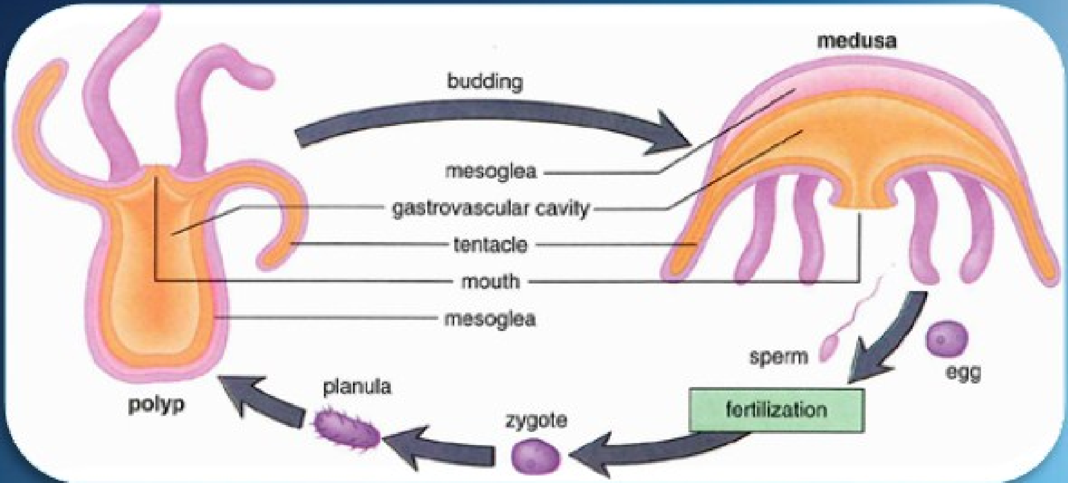
Biological Context of Reefs

Cnidarian Life Cycles

- **Life Cycle is 1 to 2 Phases**
  - **Many only have 1 phase** (Polyp or Medusa)
  - **When both are present…**
    Phase 1= Polyp (asexual phase)
    Phase 2= Medusa (sexual phase)

- Class **Anthozoa**:
  - **Sea Anemones: solitary polyps**
  - **Corals**: **colonial polyps** (usually)
- Class **Hydrozo**a:
  - **Jellyfish** with **colonial polyps** & **free-swimming medusae** phases
  - ex. *Obelia* & Portuguese man-of-war
- Class **Scyphozoa**:
  - **True Jellyfish:** small **polyp** (phase 1) & large, pronounced **medusa** (pase 2)

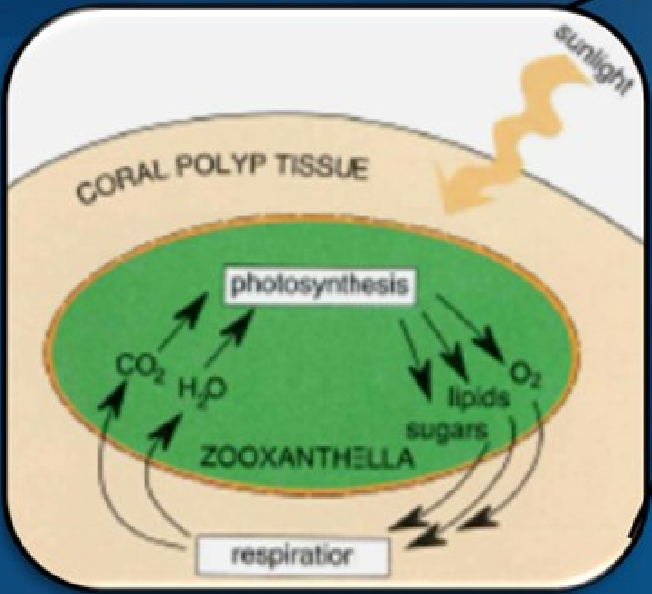
(Mader 2001; Fig. 21.4; p. 266)

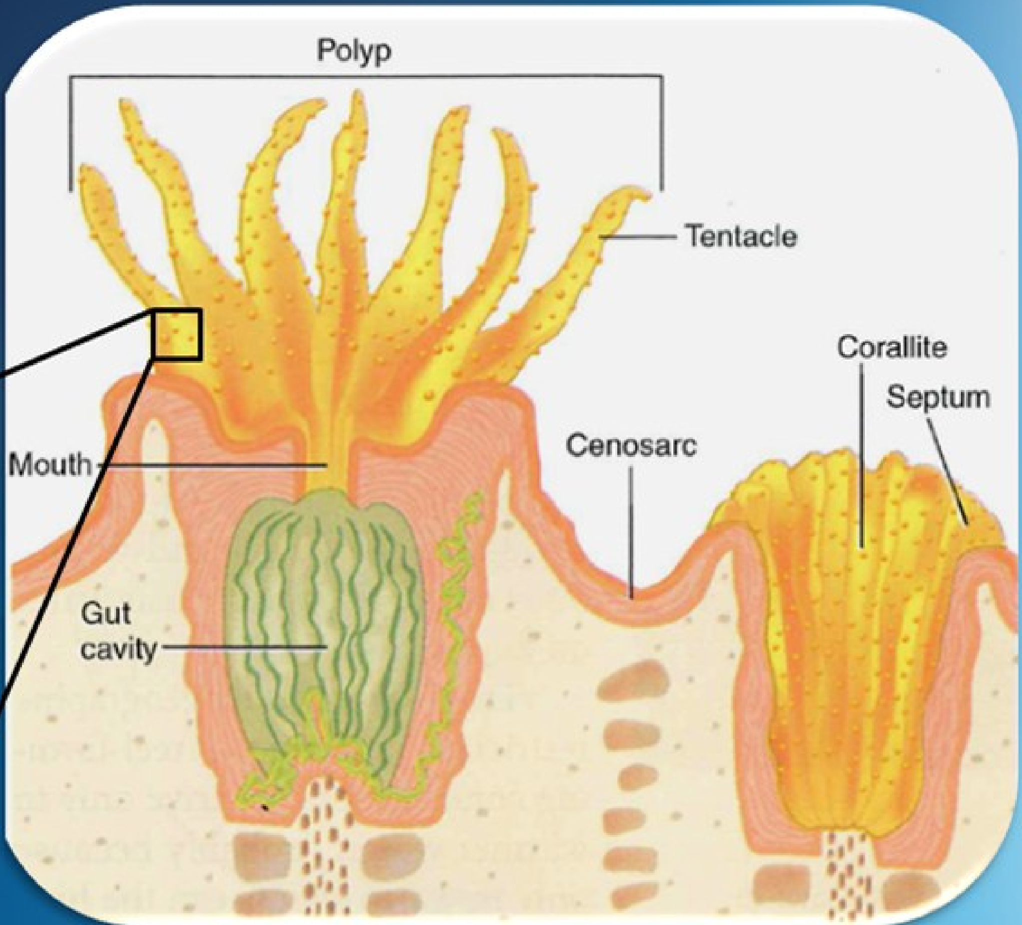


Anthozoa		Hydrozoa	Scyphozoa
Sea Anemones	**Corals**	**Jellyfish**	**True Jellyfish**
			
solitary polyp	colonial polyps (usually)	colonial polyp s with free-swimming medusa phases	small polyp with large, pronounced medusa phases

Biological Context of Reefs

Basic Coral Biology

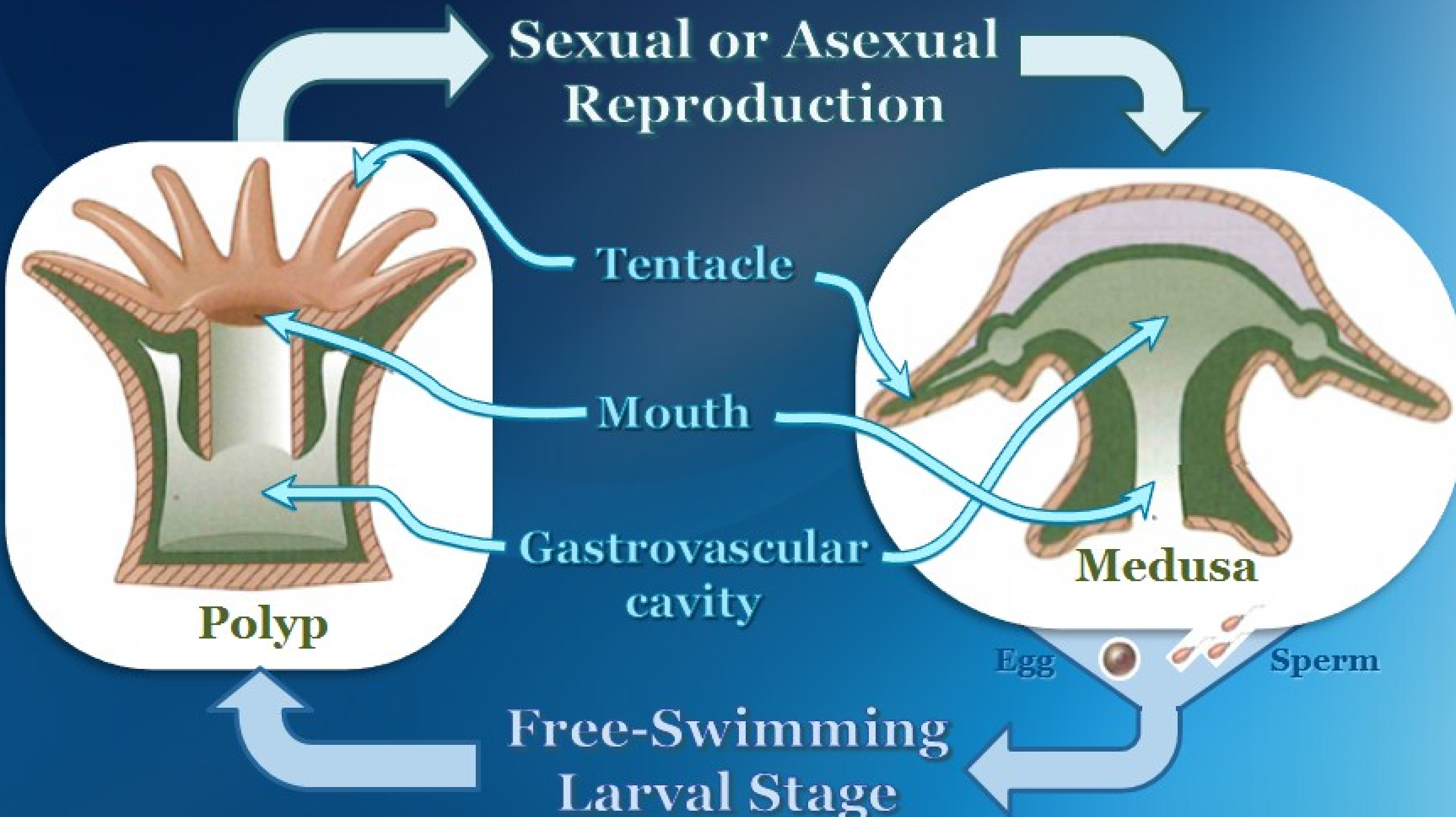




(Sumich & Morrissey 2004; Top Left: Fig. 5.12, p.136; Right: Fig. 9.2, p. 255)

Biological Context of Reefs

The **Biology**, **Reproduction**, & overall **Life Cycle** of Corals



(Adapted from: Sumich & Morrissey 2004; Fig. 5.10; p. 134)

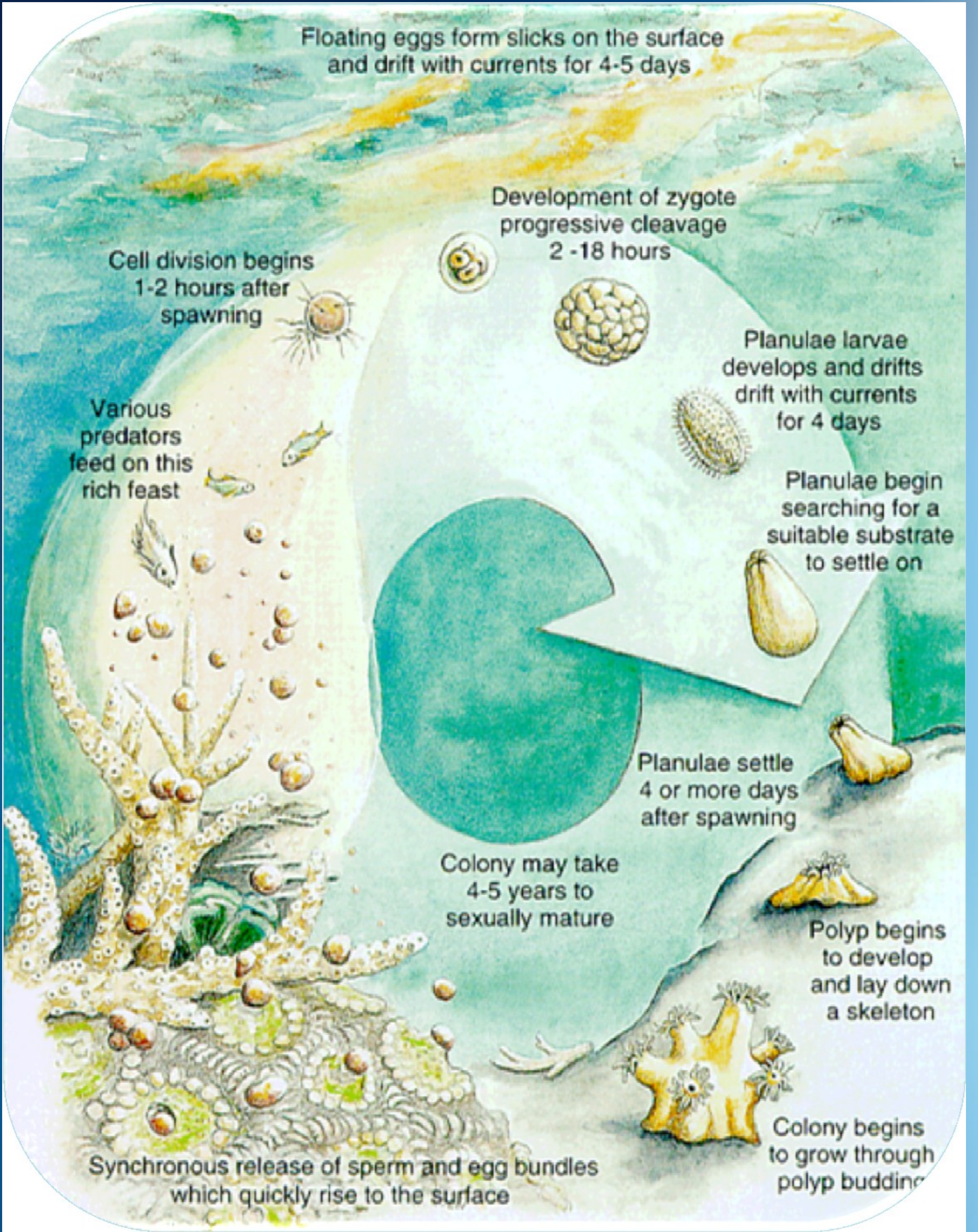
Biological Context of Reefs

Coral Growth & Reproduction

- This figure depicts Coral Reproduction by a Broadcast Spawner
- Corals need a hard substrate to attach to
- Grow in direction of current/wave action

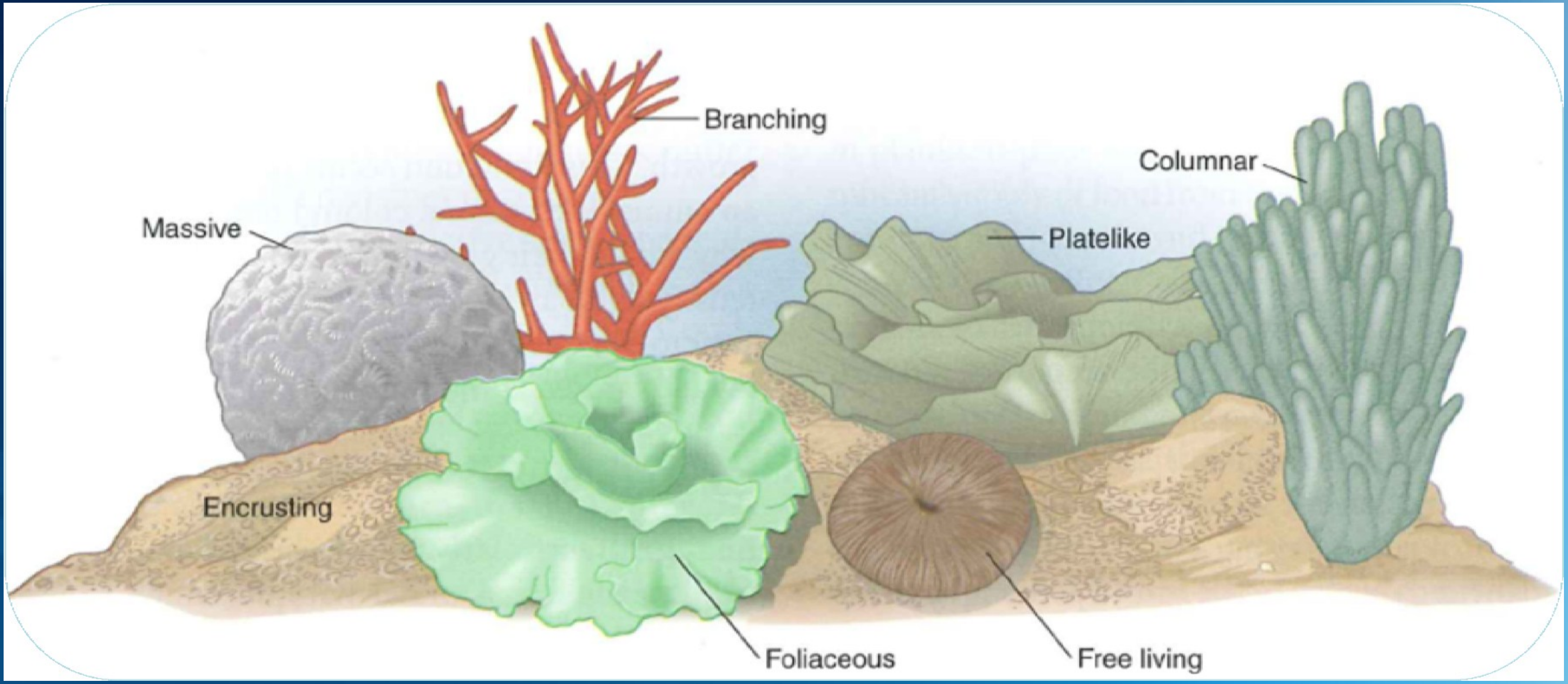
(http://www.aims.gov.au/pages/reflib/bigbank/pages/bb-09e.html)

Jennifer Lentz



Biological Context of Reefs

Coral Morphologies

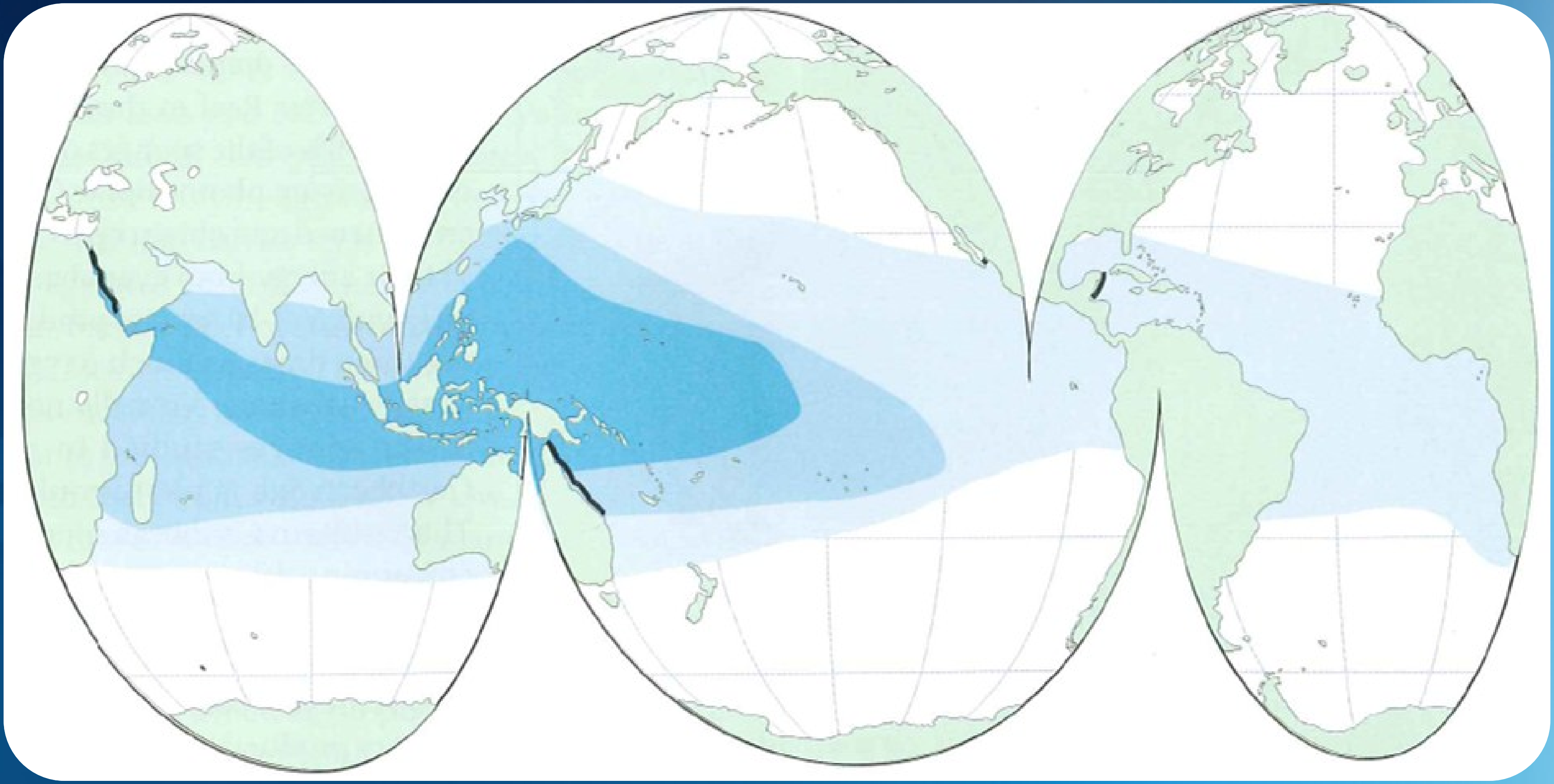


- Massive
- Branching
- Free-living
- Columnar
- Encrusting
- Foliaceous
- Platelike

(Sumich & Morrissey 2004; Fig. 9.3; p. 255)

Biological Context of Reefs

Geographic Distribution & Diversity of Corals

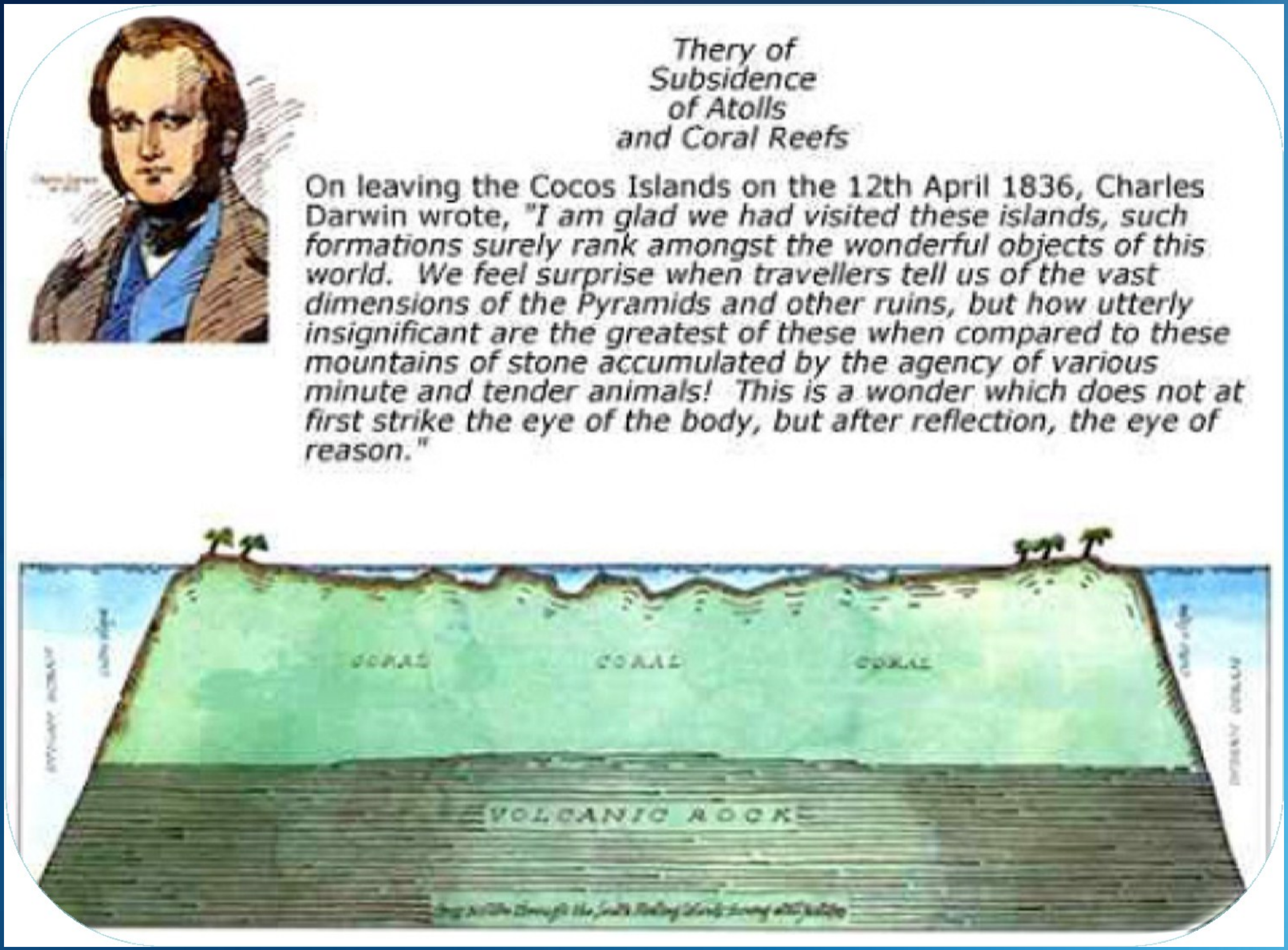


> 40 Genera **20 – 40 Genera** **< 20 Genera**

(Sumich & Morrissey 2004; Fig. 9.5; p. 257)

Geological Context of Reefs

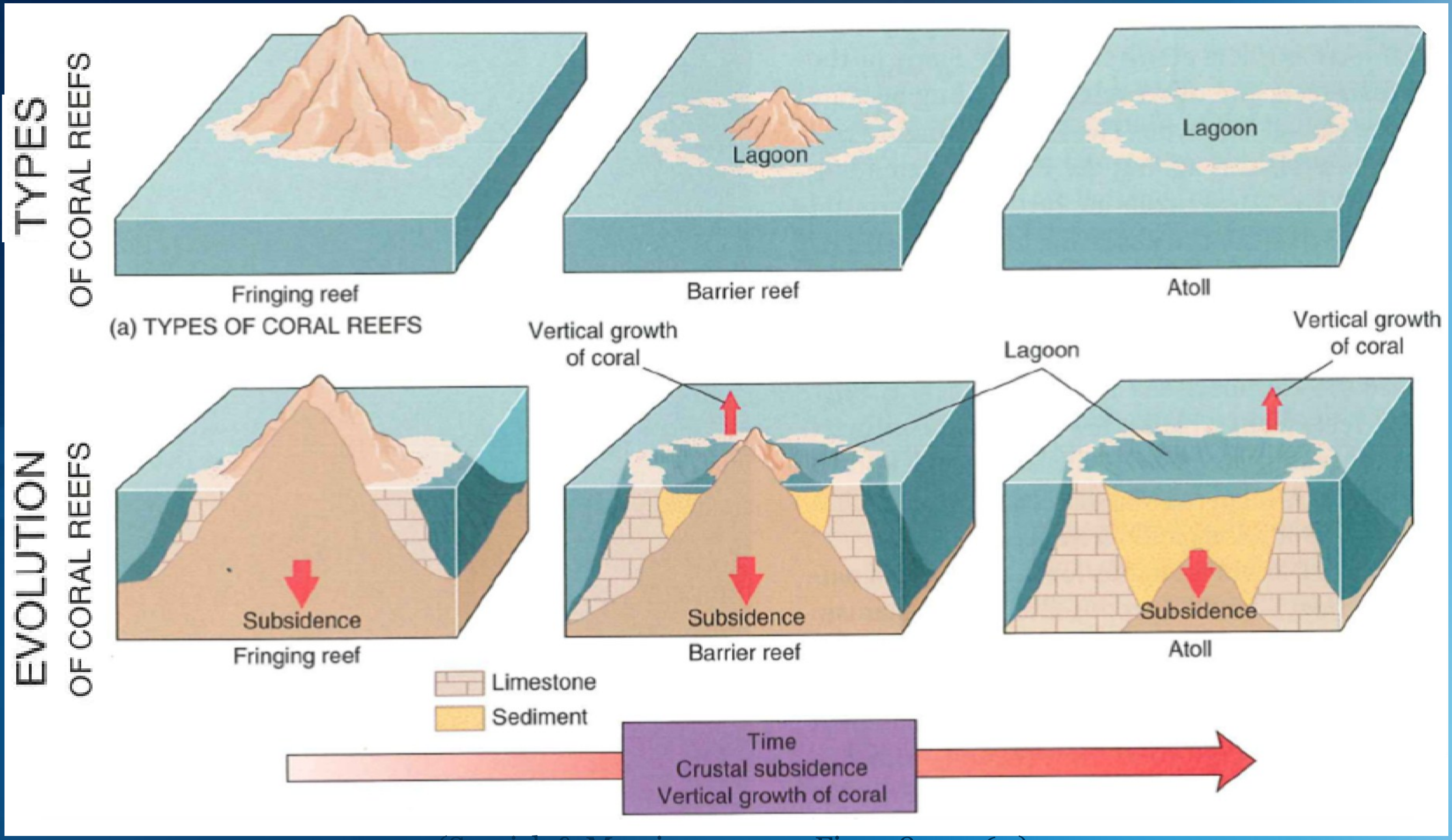
Charles Darwin & Coral Reefs



http://earthguide.ucsd.edu/team/yasuda/oceanography/tectonics/atolldarwin.jpg

Geological Context of Reefs

Types & Evolution of Coral Reefs

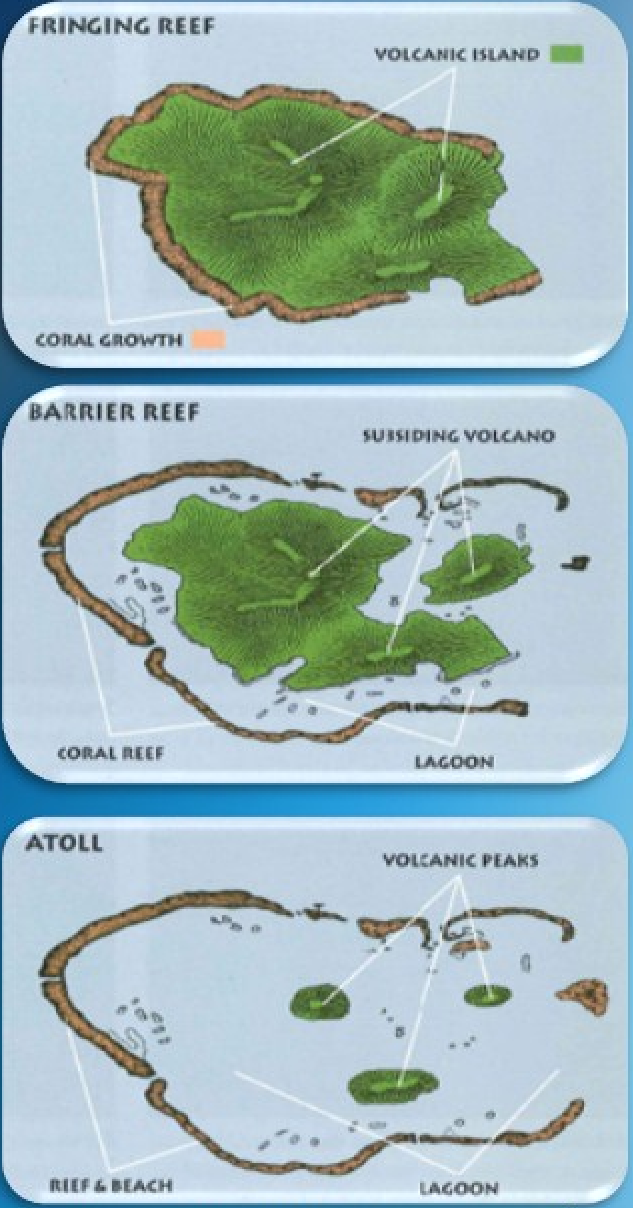


(Sumich & Morrissey 2004; Fig. 9.8; p. 260)

Geological Context of Reefs

Types & Evolution of Coral Reefs

- **Fringing Reefs**
  - Cling to land
  - Areas with low rainfall & clear water
- **Barrier Reef**
  - Separated from land by a **lagoon**
  - Great Barrier Reef is the largest structure made by living organism (135,000 mi^2)
- **Atolls**
  - Ring-shaped island of coral reefs surrounding a lagoon
  - **Formation**: Volcano → Fringing reef → Barrier reef → Atoll
  - > 1000 feet of coral fragments beneath present reefs

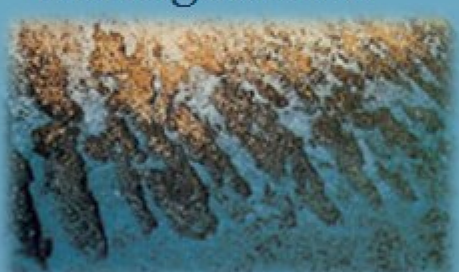


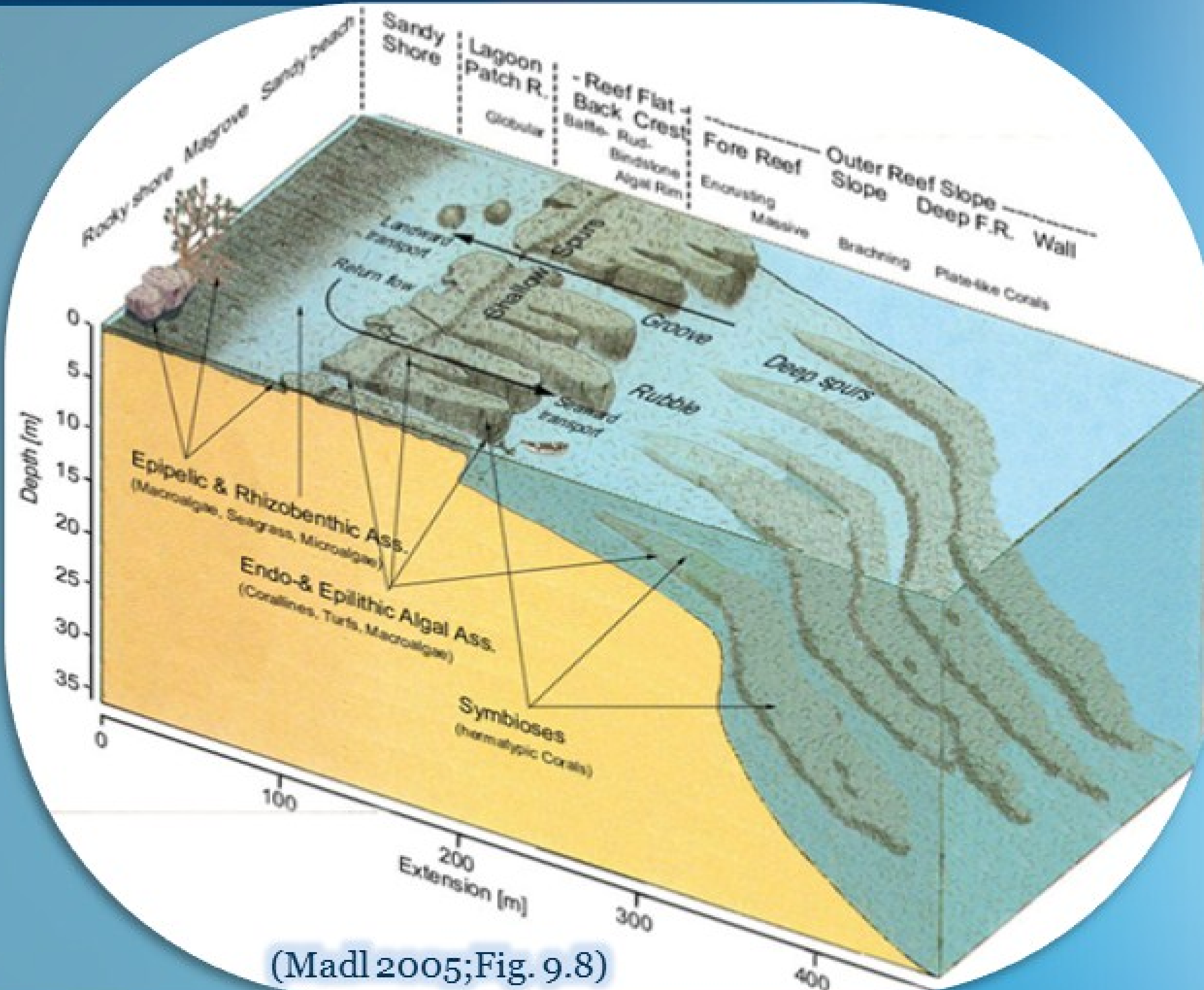
(Figures: Tackett & Tackett 2002; p. 31)

Geological Context of Reefs

Types & Evolution of Coral Reefs

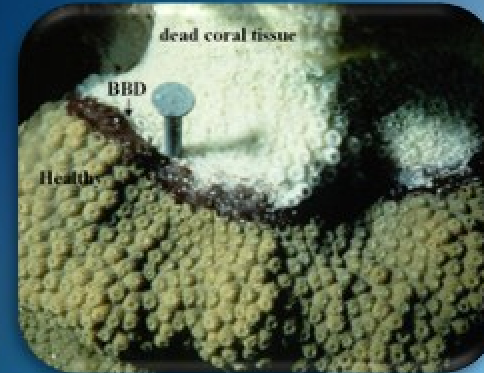
- **Spur & Groove Formations**
  - Adaptation to Wave Energy & Currents
  - Mechanism for Sediment Removal during storms



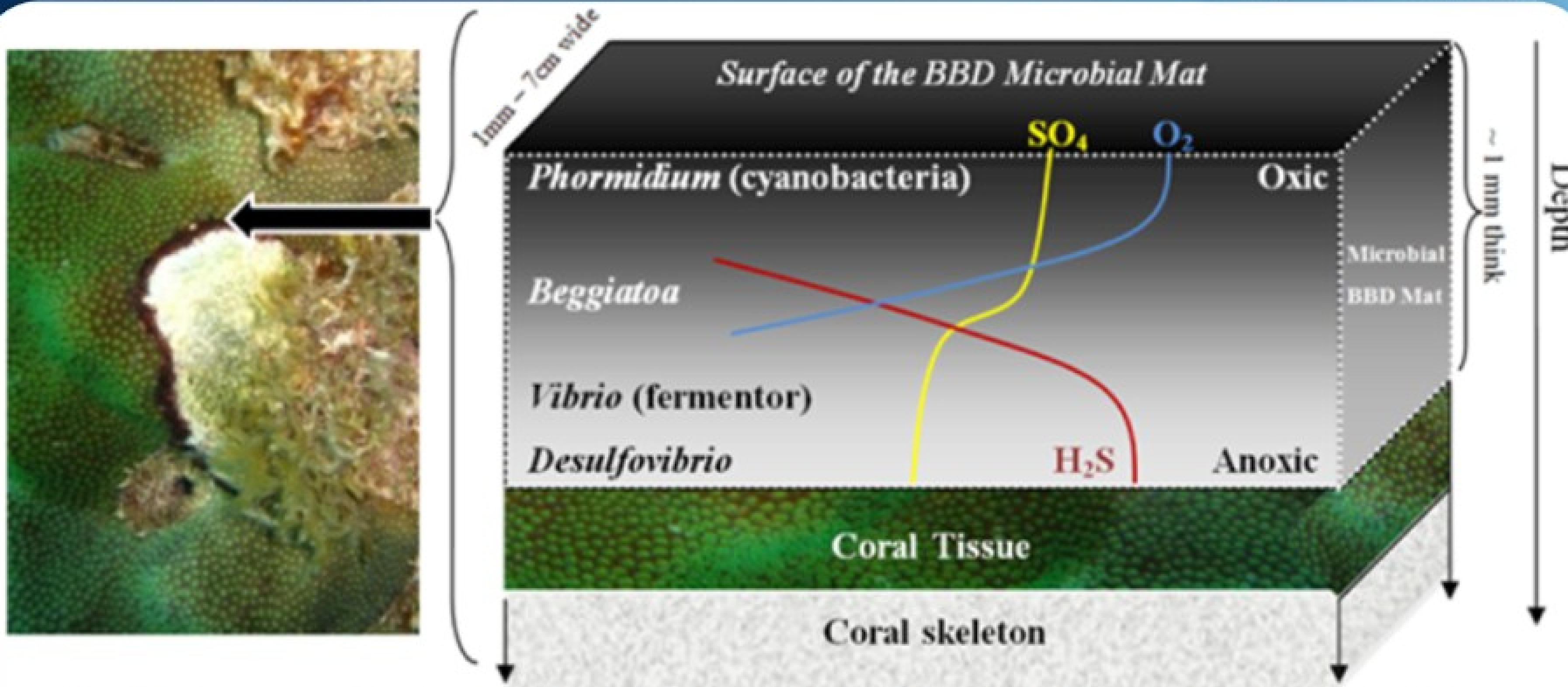


(Madl 2005;Fig. 9.8)

Coral Diseases



Black Band Disease (BBD)



Stylistic cross-section of the dominant microbes of the microbial consortium making up the BBD mat. *Note: this diagram is not done to scale.*

(Lentz 2006, unpublished.)