Advances in Biology Laboratory Education
Publication of the Association for Biology Laboratory Education
Volume 41, Article 21, 2020

An Examination of Algal Morphology and Toxicity through Experiential Learning

Kelsey Andersen, McKenzie Bahl, Susan Wright, Paul Mendoza, and Sarah E. Ruffell

University of Pittsburgh at Bradford, Biology, 300 Campus Dr, Bradford PA 16701USA
(**kea55@pitt.edu; mjb242@pitt.edu; sjw80@pitt.edu; pjm100@pitt.edu; ruffell@pitt.edu**)

The purpose of this activity was to familiarize students with the key morphological traits of each algal phyla. With this knowledge, they select harmful and health species based on a dichotomous key, and discuss the resulting health effects if consumed. This exercise is designed for undergraduate students with basic knowledge of algal species as well as prior experience with classifying organisms and identifying morphological features. It can be completed individually or in pairs, and takes approximately one hour to complete. Students will progress through three stations, beginning with labeling microalgae and macroalgae diagrams. Once completed, they progress to the next two stations, where they will select toxic or non-toxic algal strains, using the dichotomous key and morphology, to simulate the creation of a toxic or non-toxic mixture. This exercise is unique because it provides experiential learning relating to basic algal morphology.

Keywords: algae, classifying, morphology, experiential learning approach, phycology, pedagogy

Introduction

Algae are a diverse group of photosynthetic organisms which can range from health to harmful. Certain algal strains can be incorporated in to recipes and provide a nutritious source of proteins and lipids, while others produce toxins that can be lethal. The most common toxins produced by algae are cyanotoxins, saxitoxins, and zootoxins (Humbert 2009). Exposure to these toxins can damage the kidneys, heart, and liver, cause respiratory problems and even death (Humbert 2009; Van der Merwe 2014). These toxins can accumulate in aquatic ecosystems affecting organisms at all trophic levels (Ocean Data Center).

This experiential learning activity provides students with the opportunity to categorize algal species by their morphology and classification, while emphasizing the different types of algae that inhabit marine and freshwater environments.

Station 1: Algae Diagrams

After students have been divided into pairs, each pair will label a diagram of a macroalgae and microalgae. Once completed groups must verify answers with instructor before proceeding to station 2 and 3.

Station 2: Identifying Toxic Organisms

Using the dichotomous key, students will identify which species of algae are toxic. Once identified, students will simulate the act of creating a toxic smoothie using paper images of the algal strains. In the handout, groups must state which organisms were used to create the toxic algae smoothie, as well as what they think the outcome will be if consumed.

Station 3: Identifying Non-Toxic Organisms

Students at the third station will repeat the same steps as the second station, however they will be identifying the non-toxic algae. Similarly, students will design a smoothie, however this will be a non-toxic smoothie, where they will outline the health benefits if consumed.

Discussion

After all students have completed all three stations and answered all required questions, the class will come together for discussion. The class will review which organisms they chose at each station and the reasoning that led to those answers. The post activity questions should be answered by students during this discussion period

Student Outline

Harmful and Healthy Algae: Using Algal Morphology to Differentiate Between Algal Types

The following handouts contain multiple parts that are split into three different stations. The first section of the handout discusses the first station and contains 2 questions pertaining to that station. In the second and third portion of the handout, students will create toxic and nontoxic smoothies and answer the corresponding questions.

In this scenario, you will play the role of Dr. Cyan O. Bacteria. You are trying to save the world from intoxication due to dangerous algae.

Introduction:

Hello Dr. Cyan O. Bacteria, Your nemesis Dr. Dia Tome, from AHL Industries, plans to release a weapon that will kill all algae worldwide. You have been hired by the United States government to stop them! In order to destroy this new weapon, you must distract the employees at AHL industries, so that you can sneak in to the lab. To prevent detection, you hide in a smoothie truck which is providing free samples to employees at AHL Industries. You will use the supplies in the smoothie truck to make harmful smoothies that will make Dr. Dia Tome and her team sick. This will give your team enough time to sneak inside and destroy the weapon. You will also create a healthy, non-toxic smoothie for your own team to drink after you have saved the world!

Prelab Questions:

→ Name 2 health benefits of algae following human consumption.

→ Name 2 negative impacts of algae following human consumption.

Station 1: Complete the diagrams identifying basic features of an algal cell and answer the questions below. Have your instructor check your answers to ensure you have completed the handouts correctly before moving to the next step. Diagrams are listed in Appendix A.

→ Why is it important to know how to identify parts of an algal cell?

→ When would you be able to use this knowledge in a real-life scenario?

Station 2: Use the dichotomous key and photos provided to identify toxic organisms and create a toxic smoothie for your nemesis Dr. Dia Tome. Fill out the table only for the toxic organisms and list 2 interesting facts for each using the provided materials.

→ What ingredients did you use?

→ In your opinion, what effects will result from the combination of these ingredients?

Station 3: Use the dichotomous key and photos provided to identify non-toxic organisms and create a healthy smoothie for your team. Fill out the table only for the non-toxic organisms and list 2 interesting facts for each using the provided materials.

→ What ingredients did you use?

→ In your opinion, what effects will result from the combination of these ingredients?

Post-Lab Questions:

→ Why is it important to know how to identify harmful algae versus harmless algae?

→ How can you, as a student, use this information to educate your friends and family when going somewhere that has a risk of harmful algae encounters?

Materials

A beaker for each student or pair of students is needed for the stations where students will be creating smoothies. Image cutouts of algae will be needed at final two stations. Students will need all handouts at all stations in order to complete questions. Optional materials include latex gloves and lab apron. If students feel they need additional supplies, they are instructed to ask the lab coordinator(s).

Notes for the Instructor

Instructor should take into consideration time limitations at each station. Students should take no longer than 20 minutes at each station to complete the activity and required questions.

The purpose of this experiment was to create two smoothies of algae, one toxic and one non-toxic, was notably enjoyed by all students who participated in this laboratory exercise and helped them identify the differences between toxic and non-toxic algae.

Please refer to the Appendix for a significant amount of resources, including worksheets, morphology images, answer keys, dichotomous key, etc.

Cited References

Brooker BJ, Widmaier EP, Graham LE, Siling PD. 2017. Biology 4th edition. New York: McGraw-Hill Education

NCBI Taxonomy Browser. [date unknown]. Taxonomy Browser. Available from: https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Info&id=3077&lvl=3&lin=f&keep=1&srchmode=1&unlock

Cohen J. 2019. 14 amazing health benefits of kelp (seaweed) + side effects. Selfhacked. Available from: https://selfhacked.com/blog/kelp/

De Kluijver M, Gijswijt G, De Leon R, Da Cunda I. [date unknown]. Interactive Guide to Caribbean Diving. Available from: http://species-identification.org/species.php?species_group=caribbean_diving_guide&menuentry=soorten

Fisheries Global Information System (FAO-FIGIS). c.2019. Fisheries Global Information System (FIGIS): FI Institutional Websites. In: FAO Fisheries and Aquaculture Department [online]. [Cited 27 March 2019]. Available from: http://www.fao.org/fishery/species/2790/en

Guiry MD. 2018. *Alexandrium tamarense* (Lebour) Balech. National University of Ireland: World Wide Electronic Publication. [updated 2002 Apr 26; cited 2018 Sept 3]. Available from: http://www.algaebase.org/search/species/detail/?species_id=40299

Gwaltney-Brant SM. 2017. Zootoxins. In: Gupta RC, editor. Reproductive and developmental toxicology. Cambridge, MA: Academic Pres p.766.

Humbert JF. 2009. Toxins of cyanobacteria. In: Gupta RC, editor. Handbook of toxicology of chemical warfare agents. Cambridge, MA: Academic Press. p. 372-374.

Intergovernmental Oceanographic Commission of UNESCO Harmful Algal Bloom Programme. [date unknown]. Oostende, Belgium: UNESCO/IOC Project Office for IODE. Available from: http://hab.ioc-unesco.org/index.php?option=com_content&view=article&id=5&Itemid=16

Ivin VV, Shevchenko OG, Orlova TY. 2016. Scallops of northwestern pacific russian federation. In: Shumway SE, Parsons JGJ, editors. Scallops-biology, ecology, aquaculture, and fisheries. Elsevier Science and Technology. p. 971.

Jennings K. 2017. 9 impressive health benefits of chlorella. Healthline. Available from: https://www.healthline.com/nutrition/benefits-of-chlorella#section2

Jiang Y, Xiao P, Yu G, Sano T, Pan Q, Li R. 2012. Molecular basis and phylogenetic implications of deoxycylindrospermopsin biosynthesis in the cyanobacterium *Raphidiopsis curvata*. Appl Environ Microbiol 78:2256–2263. doi:10.1128/AEM.07321-11

Kipp RM. 2006. NOAA-Great Lakes Environmental Research Laboratory. [updated 2007 Feb 19; cited 2006]. Available from: https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/cylindro_factsheet.html

Kuwata A., Jewson DH. 2015. Ecology and Evolution of Marine Diatoms and Parmales. In: Ohtsuka S, Suzaki T, Horiguchi T, Suzuki N, Not F. editors.

Marine Protists. Springer, Tokyo: Springer Japan. p. 251-275

Magaña HA, Contreras C, Villareal TA. 2003. A historical assessment of *Karenia brevis* in the western Gulf of Mexico. Harmful Algae. 2(3): 163-171. Available from: https://doi.org/10.1016/S1568-9883(03)00026-X

Masojídek J, Torzillo J. 2008. Mass Cultivation of Freshwater Microalgae. Encyclopedia of Ecology. p. 2226-2235. Available from: https://doi.org/10.1016/B978-0-12-409548-9.09373-8

Men'shova RV, Ermakova SP, Um BH, Zvyagintseva TN. 2013. The composition and structural characteristics of polysaccharides of the brown alga *Eisenia bicyclis.* Russ J Mar Biol. 39 (208): 208–213. Available from: https://doi.org/10.1134/S1063074013030103

Morphology and Taxonomy-Introduction. [accessed 2019 Sep 15]. Available from http://formosa.ntm.gov.tw/seaweeds/english/b/b1_01.asp

O'Brien S. 2018. 7 surprising health benefits of eating seaweed. Healthline. Available from: https://www.healthline.com/nutrition/benefits-of-seaweed

Ocean Data Center. [date unknown]. Phytoplankton identification. University of California Santa Cruz: CeNCOOS and HABMAP. Available from: http://oceandatacenter.ucsc.edu/PhytoGallery/toxigenic.html

Ocean Data Center. [date unknown]. Red tides and harmful algal blooms. University of California Santa Cruz: CeNCOOS and HABMAP. Available from: http://oceandatacenter.ucsc.edu/PhytoGallery/HABS_redtides.html

Osterbauer PJ, Dobbs MR. 2009. Neurobiological weapons. In: Dobbs MR, editor. Clinical neurotoxicology. Philadelphia, PA: Saunders Elsevier. p. 641

Robinson N, Winberg P, Kirkendale L. 2013. Genetic improvement of macroalgae: status to date and needs for the future. Journal of applied phycology, 25 (3): 703-716. Available from: doi: 10.1007/s10811-012-9950-x

Van der Merwe D. 2014. Freshwater cyanotoxins. In: Gupta RC, editor. Biomarkers in toxicology. Cambridge, MA: Academic Press. p. 545.

Wells E. 2007. Water Framework Directive – coastal water rocky shore monitoring: Field guide to British seaweeds. Environment Agency, Bristol. p. 25, 40, 59, 102, 107. Available from: http://magnusgaard.com/onewebmedia/EA%20Seaweed%20reference%20manual.pdf

Acknowledgments

Thank you to the writing center, at the University of Pittsburgh at Bradford, for your assistance with editing. Additionally, this research was financially supported by a Faculty Development Grant at the University of Pittsburgh at Bradford.

About the Authors

Kelsey Andersen is a biology major who hopes to go to graduate school to obtain a Masters of Public Health in epidemiology or reproductive health.

McKenzie is a biology major who hopes to work in the field of conservation biology to research techniques to prevent endangered wildlife species from becoming extinct.

Paul Mendoza is a biology major who hopes to work in a hospital laboratory after he graduates from university.

Susan Wright is a biology major who hopes to work in the field of environmental laboratory science after she graduates from university.

Sarah E. Ruffell teaches microbiology and phycology, while continuing her research on pedagogy and curriculum.A s of 2020, she has begun a new position at the University of Waterloo and would be happy to answer any questions you have at her new email sruffell@uwaterloo.ca.

Appendix A: Student Resources

Diagrams

Algal Morphology

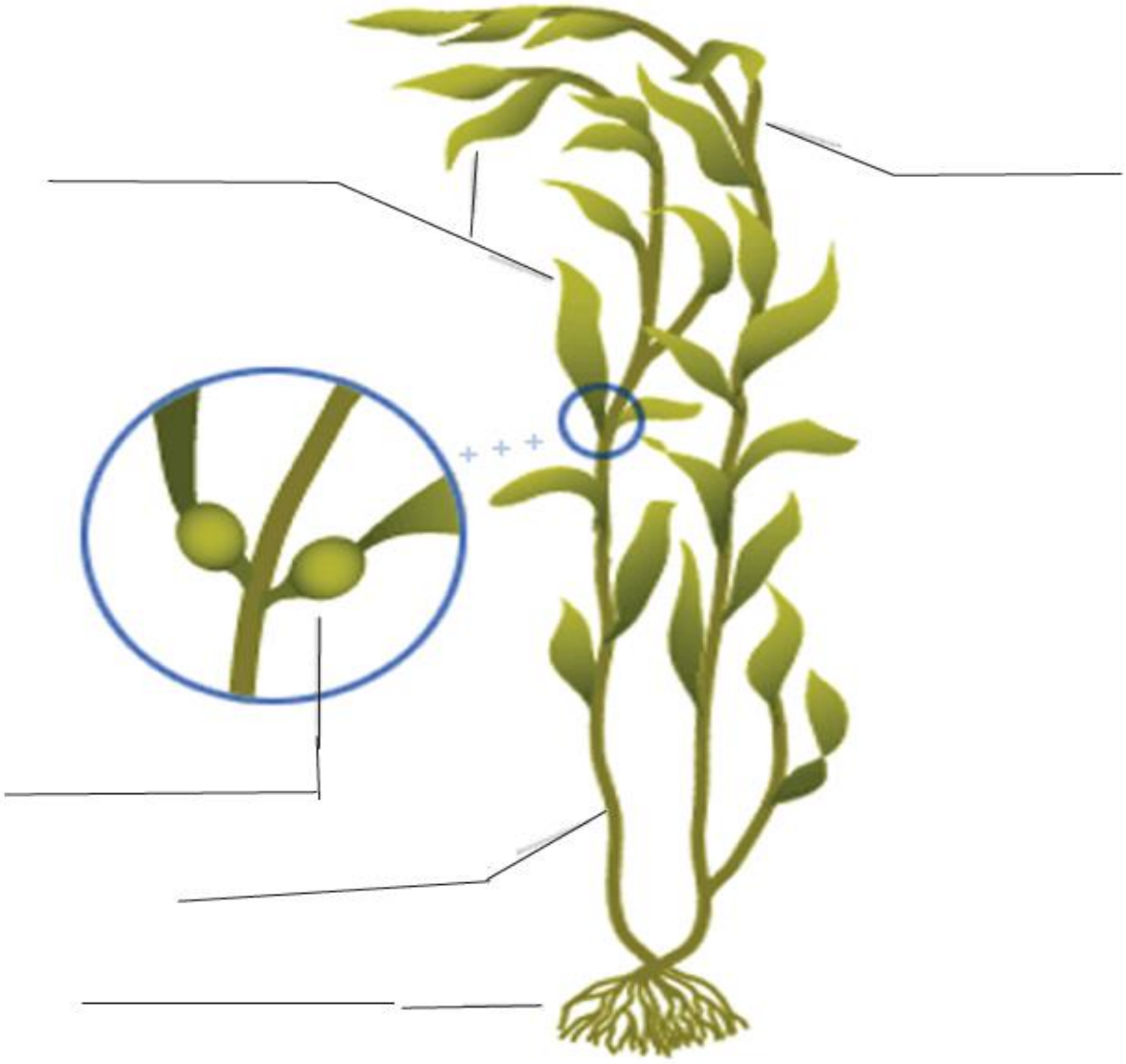

Figure 1. Alga morphology diagram.
Reprinted from Microscope Diagram and Functions. Clipart Panda Free Images. EasyFreeClipArt.com

Green Algae Cell

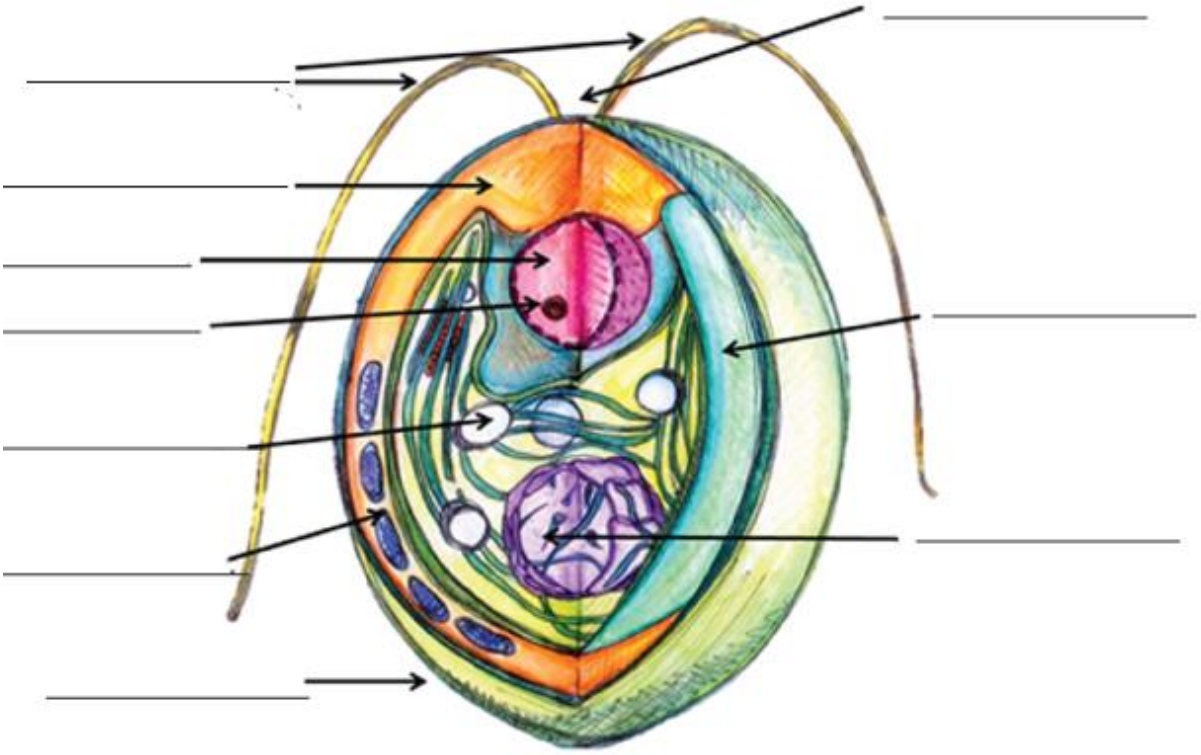

Figure 2. Chlorophyte (Green Algal) Cell Diagram.Cross Section of Chlamydomonas reinhardtii. Ninghui Shi. `https://commons.wikimedia.org/wiki/File:Cross_section_of_a_Chlamydomonas_reinhardtii_algae_cell,_a_3D_representation .jpg

Cyanobacterium Cell

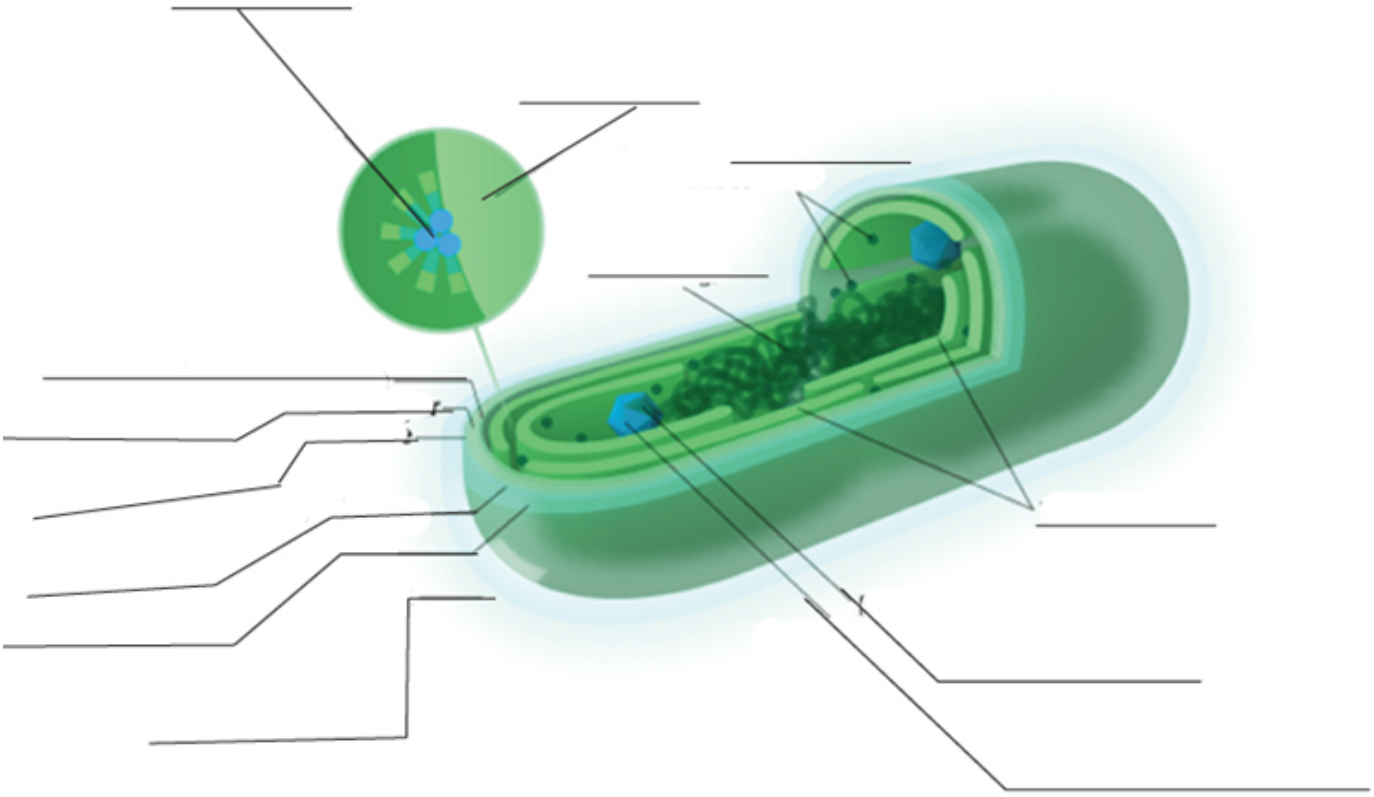

Figure 3. Cyanobacteria (Blue- Green Alga) Cell Diagram.
Reprinted from Diagram of a cyanobacterium. Kelvinsong. Wikimedia Commons.

Cyanobacterium Cell

Word Bank and Glossary for Diagrams*

Frond: The entire structure of the algal body

Gas Bladder: Allows fronds to float towards the water's surface to absorb sunlight for photosynthesis

Stipe: "Stem-like"structure that provides support for the algal body

Blades: "leaf-like" structure

Holdfast: Allows algae to attach to surfaces through use of a glue-like substance, resembles roots

Flagella: "Thread-like" structure that allows the cell to move

Cytoplasm: Thick solution that fills the cell and holds organelles in place

Nucleus: Organelle that contains genetic material, large and circular

Starch Granules: Energy reserves found throughout the cell, white in color

Mitochondria: Organelle found in multiples, site of respiration and energy production

Cell Membrane: Separates the inside of cells from its environment

Chloroplast: "Cup-shaped" organelle that contains chlorophyll and is the site of photosynthesis

Pyrenoid: Compartments found in the chloroplast

Phycoblilisome: Protein complexes that are attached to the thylakoid membrane

Thylakoid Membrane: Found in photosynthetic cells, surrounds the phycobilisomes and thylakoids

Ribosomes: Small particle-like organelles that contain RNA

Nucleoid: An organelle that is irregularly shaped (looped-circles) that contain genetic material

Thylakoids: Flattened sheets found in photosynthetic microorganisms

RuBisCO: Enzyme found in chloroplasts involved with fixing CO2 found in carboxysomes

Carboxysome: Many-sided compartments that holds RuBisCO

Slime Coat: Outer most layer that functions to protect cells from environmental dangers

Capsule: Below The slime coat, made of a polysaccharide layer

Mucoid Sheath: A layer of cellular protection that resembles mucus

Peptidoglycan Layer: Provides structure to the cell, found below the outer membrane

Outer Membrane: Makes up the cell wall surrounds the peptidoglycan layer and cell membrane

*All definitions from : Brooker BJ, Widmaier EP, Graham LE, Siling PD. 2017. Biology 4th edition. New York: McGraw-Hill Education

Key for Identifying the Toxicity of Algae

1a. Specimen is a macro-organism[1] . . . . . Go to 2
1b. Specimen is a microorganism[1] . . . . . Go to 3

2a. Algae brown in color[1] . . . . . Go to 4
2b. Algae is not brown in color[1] . . . . . Go to 5

3a. Microorganism is found in marine habitats[1]. . . . . ..Go to 9
3b. Microorganism is found in freshwater habitats[1]. . . . . .Go to 10

4a. Algae is 1 meter tall when mature[2] . . . . . .*Non-Toxic*
4b. Algae can be more than 1 meter tall when mature[2]. . . . . .Go to 6

5a. Algae is red in color[1] . . . . . Go to 7
5b. Algae is green in color[1]. . . . . Go to 8

6a. Algae is Golden brown, with lighter color stipe, lanceolate frond, gas bladders present[2]. . . . . .. *Non-Toxic*
6b. Algae has an undivided frond, crenulate margin[2]. . . . . .*Non-Toxic*

7a. Algae has crenulate margins and grows in bush-like formation. 20-50 cm tall[2] . . . . . .*Non-Toxic*
7b. Algae posses a discoid holdfast and has a texture of thin rubber[2] . . . . . *Non-Toxic*

8a. Algae posses trumpet-shaped appendages, 30 cm tall [2] . . . . . .*Non-Toxic*
8b. Algae has a crenulate and torn margin, 30 cm tall, no stipe[2] . . . . . .*Non-Toxic*

9a. Algae possesses 2 flagella and is up to 40 micrometers in diameter[2] . . . .**Toxic**
9b. Algae does not possess 2 flagella and is more than 40 micrometers in diameter[2] . . . . . Go to 11

10a. Algae is up to 10 micrometers in size[2] . . . . . *Non-Toxic*
10b. Algae can be more than 10 micrometers in size[2]. . . . . Go to 12

11a. Algae is up to 175 micrometers in diameter and is a pennate diatom[2] . . . . . **Toxic**
11b. Algae is up to 46 micrometers in diameter and has a spherical shape[2]. . . . . ..**Toxic**

12a. Algae is up to 12 micrometers in size[2] . . . . . *Non-Toxic*
12b. Algae is more than 12 micrometers in size[2] . . . . . Go to 13

13a. Algae is 50-300 micrometers in size, produces akinetes[2] . . . . . **Toxic**
13b. Algae is 1000 to 3000 micrometers in size[2]. . . . . **Toxic**

[1]Brooker BJ, Widmaier EP, Graham LE, Siling PD. 2017. Biology 4th edition. New York: McGraw-Hill Education

[2]Morphology and Taxonomy-Introduction. [Internet]. [accessed 2019 Sep 15]. Available from http://formosa.ntm.gov.tw/seaweeds/english/b/b1_01.asp

Student Table for Recording Algae Characteristics.

Table 1. Algae characteristics.

Species Name	Features	Toxic or Non-Toxic	Facts About the Species
Alexandrium tamarense	Dinoflagellate found in coastal marine environments 25-46 micrometers in diameter brown in color and spherical (Guiry 2018)		
Chlorella vulgaris	Single-celled, green algae found in freshwater. Small and Spherical 5-10 micrometers in size possesses chlorophyll-a and chlorophyll-b (NCBI Taxonomy)		
Pseudo-nitzschia australis	found in marine waters worldwide bilaterally symmetrical Oval (pennate) diatoms 40-175 micrometers in diameter (Kuwata and Jewson 2015)		
Cylindrospermopsis raciborskii	Cyanobacteria found in freshwaters 50-300 micrometers in length produce akinetes (a cylindrical structure with a thick cell wall, that is able to produce cylindropspermopsins) (Kipp 2006)		
Arthrospira platensis	Blue Green Algae with a helical Shape 2 to 12 micrometers in size can be found in freshwater (Masojidek and Torzillo 2008)		

Raphidiosis curvata	Cyanobacteria found in all freshwaters 1000 to 3000 micrometers in size (Jiang et al. 2012)		
Eisenia bicyclis	Brown algae found in temperate Pacific Ocean waters. Possesses flattened oval (obovate) fronds Fronds are attached to a woody stipe Mature plants can be up to 1 meter tall Fronds are shed annually (Men'shova et al. 2013)		
Palmaria palmata	Red Seaweed, Grows in the Pacific and Atlantic Oceans. Has a texture of thin rubber with flattened fronds. Disk-like (discoid) holdfast. Has a short almost unnoticeable stipe. Membranous and Leathery (Wells 2007)		
Gymnodinium breve *(Karenia brevis)*	Found in warm and tropical waters. Ex: The Gulf of Mexico. Has 2 flagella. Up to 40 μm in diameter (Magaña et al. 2003)		
Undaria pinnatifida	Brown Algae, flat stipe with teeth-like (dentate) margins (edge), frond is blade-like (lanceolate) and flattened. Golden brown in color with a lighter colored stipe. Mature specimens can be 2-3 meters tall. Possesses gas bladders to float (Wells 2007)		
Pyropia tenera	Red Algae. Grows between 20-50 cm. Grows in a bush-like formation with crenulate edges. Found in the western Pacific Ocean and the Indian Ocean (FAO-FIGIS 2019)		

Saccharina japonica	Brown algae found in the northern hemisphere in temperate and cold waters. Grown on ropes in China and Japan Wave like edge (crenulate) Undivided frond Grows up to 4 meters (Robinson et al. 2013)		
Ulva lactuca	Green Algae, margin is crenulate and torn. Has a mature height of 30 cm. no stipe. Disc-shaped (discoid) holdfast soft and translucent (Wells 2007)		
Caulerpa racemosa	Green Algae, trumpet-shaped () appendages surround the stipe. Has a mature height of 30 cm. can be branched or clumped together (De Kluijver et al.)		

Appendix B: Instructor Resources

Answers to Diagrams

Algal Morphology

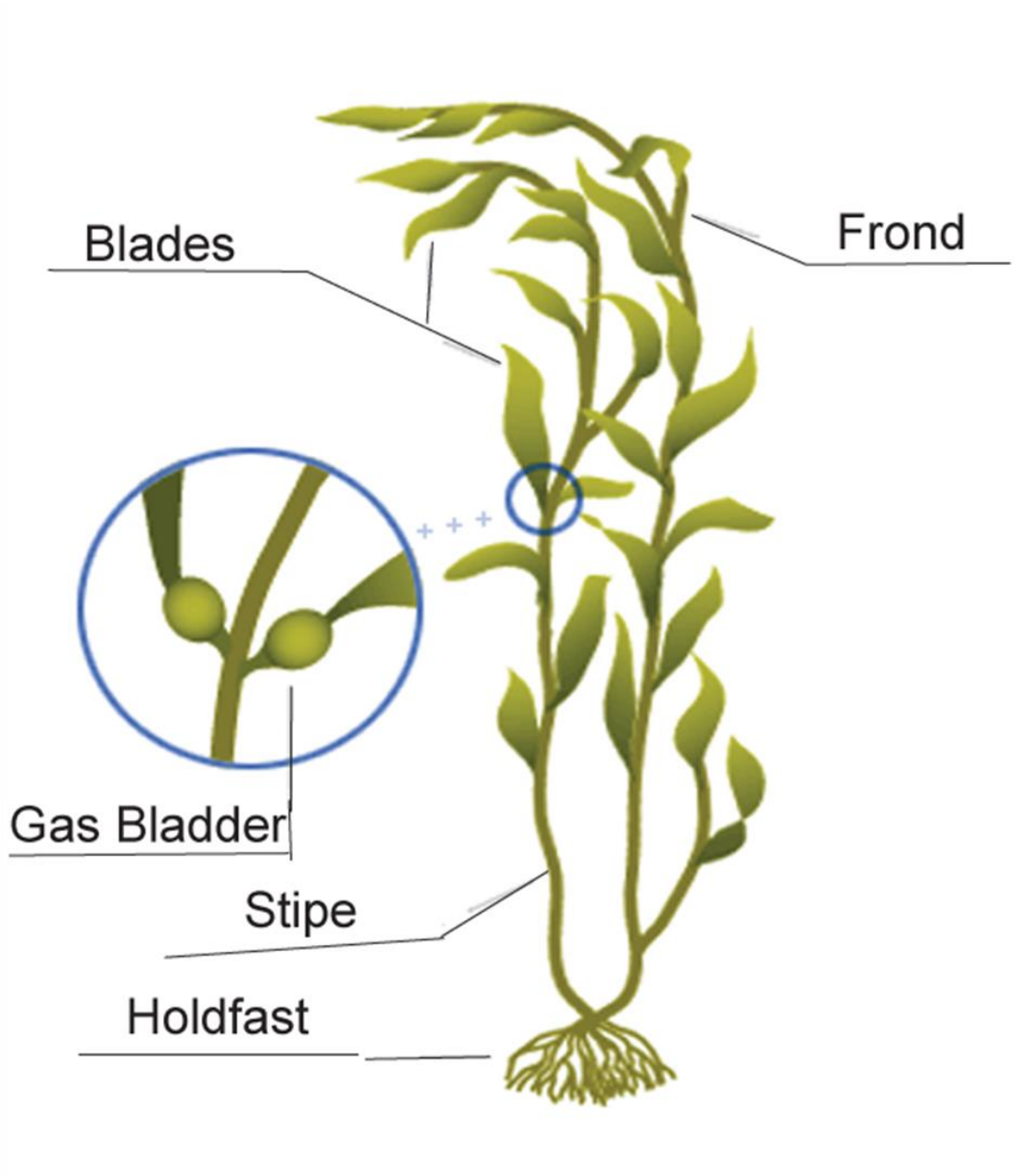

Figure 4. Alga morphology diagram.
Reprinted from Microscope Diagram and Functions Clipart Panda Free Images. EasyFreeClipArt.com

Green Algae Cell

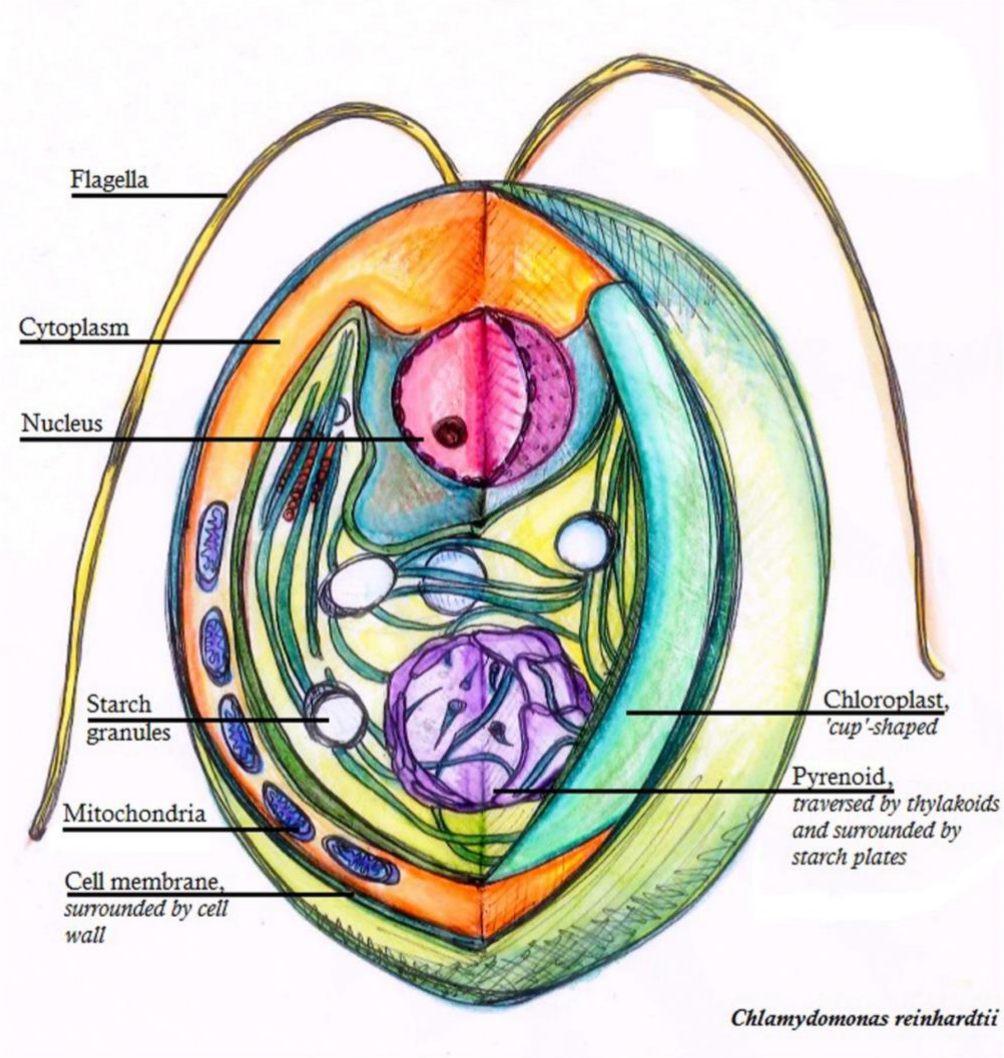

Figure 5. Chlorophyte (Green Algal) Cell Diagram
Cross Section of *Chlamydomonas reinhardtii*. Ninghui Shi.
https://commons.wikimedia.org/wiki/File:Cross_section_of_a_Chlamydomonas_reinhardtii_algae_cell,_a_3D_representation.jpg

Cyanobacterium Cell

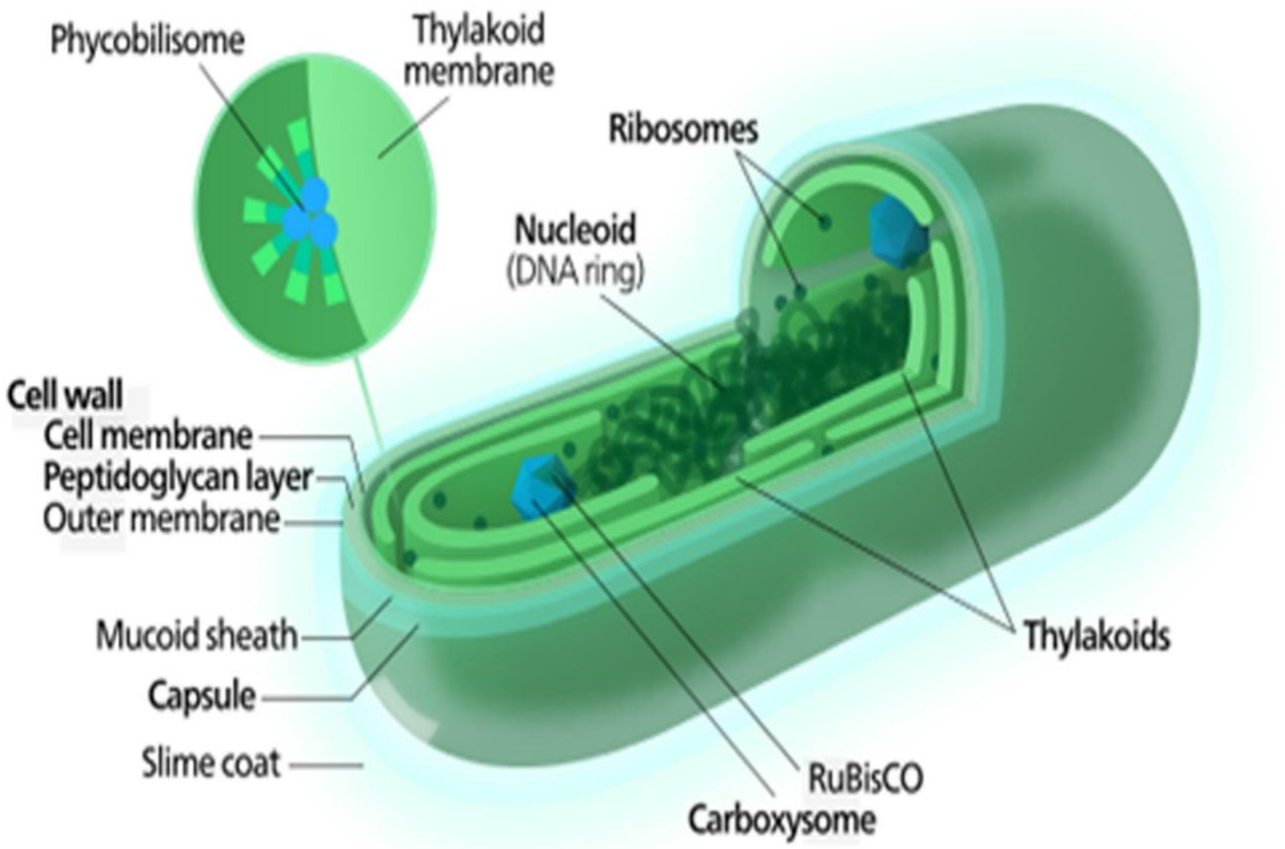

Figure 6. Cyanobacterium
Reprinted from Diagram of a Cyanobacterium. Kelvinson. Wikimedia Commons.

Table 2. Characteristics of Algae with Answers

Table 2. Characteristics of Algae.

Species Name	Features	Toxic or Non-Toxic	Facts about the Species
Alexandrium tamarense	Dinoflagellate found in coastal marine environments 25-46 micrometers in diameter brown in color and spherical (Guiry 2018)	Toxic	produces saxitoxins exposure to saxitoxins causes respiratory failure and death within 24 hours; 0.2 mg is lethal to the average adult human (Ocean Data Center)
Chlorella vulgaris	Single-celled, green algae found in freshwater. Small and Spherical 5-10 micrometers in size possesses chlorophyll-a and chlorophyll-b (NCBI Taxonomy)	Non-Toxic	Must be taken as a supplement (available in capsule, tablet, powder, and extraction) Contains protein, Vitamin B12, antioxidants, Zinc, Omega 3s, Potassium, Calcium, Folic acid, Fiber helps to detox the body Enhances the immune system by producing antibodies Improves blood sugar levels helps manage respiratory diseases eye health Liver health, improved digestion, relieves PMS (Jennings 2017)
Pseudo-nitzschia australis	found in marine waters worldwide bilaterally symmetrical Oval (pennate) diatoms 40-175 micrometers in diameter (Kuwata and Jewson 2015)	Toxic	produces the zootoxin domoic acid. Exposure to this acid is usually not lethal to humans. Symptoms include (Ocean Data Center)
Cylindrospermopsis raciborskii	Cyanobacteria found in freshwaters 50-300 micrometers in length produce akinetes (a cylindrical structure with a thick cell wall, that is able to produce cylindropspermopsins) (Kipp 2006)	Toxic	produces the cyanotoxin cylindropspermopsin. Exposure to cylindropspermopsins in high amounts can cause tubular necrosis of the kidneys and myocardial hemorrhage of the heart, as well as severe kidney and liver damage in less high concentrations (Ocean Data Center)
Arthrospira platensis	Blue Green Algae with a helical Shape 2 to 12 micrometers in size can be found in freshwater (Masojidek and Torzillo 2008)	Non-Toxic	Contains proteins, essential fatty acids, fiber, antioxidants, and Iron May reduce blood pressure Anti-inflammatory (O'Brien 2018)
Raphidiosis curvata	Cyanobacteria found in all freshwaters 1000 to 3000 micrometers in size (Jiang et al. 2012)	Toxic	produces the cyanotoxin cylindropspermopsin. Exposure to cylindropspermopsins in high amounts can cause tubular

			necrosis of the kidneys and myocardial hemorrhage of the heart, as well as severe kidney and liver damage in less high concentrations (Ocean Data Center)
Eisenia bicyclis	Brown algae found in temperate Pacific Ocean waters. Possesses flattened oval (obovate) fronds Fronds are attached to a woody stipe Mature plants can be up to 1 meter tall Fronds are shed annually (Men'shova et al. 2013)	Non-Toxic	Used in Soups. Helps digestive health Natural source of vitamins A, B1, B2, C, D, and E. Contains minerals including Zinc, Calcium, and Potassium (O'Brien 2018)
Palmaria palmata	Red Seaweed, Grows in the Pacific and Atlantic Oceans. Has a texture of thin rubber with flattened fronds. Disk-like (discoid) holdfast. Has a short almost unnoticeable stipe. Membranous and Leathery (Wells 2007)	Non-Toxic	Necessary for thyroid hormones Good Source of fiber Can help reduce blood pressure Boosts Weight Loss Helps production of thyroid hormones improves iodine deficiency may reduce sugar in diabetes (O'Brien 2018)
Gymnodinium breve (Karenia brevis)	Found in warm and tropical waters. Ex: The Gulf of Mexico. Has 2 flagella. Up to 40 μm in diameter (Magaña et al. 2003)	Toxic	Produces saxitoxins. Exposure to saxitoxins causes respiratory failure and death within 24 hours; 0.2mg is lethal to the average adult human (Ocean Data Center)
Undaria pinnatifida	Brown Algae, flat stipe with teeth-like (dentate) margins (edge), frond is blade-like (lanceolate) and flattened. Golden brown in color with a lighter colored stipe. Mature specimens can be 2-3 meters tall. Possesses gas bladders to float (Wells 2007)	Non-Toxic	Used in Soups. Helps digestive health Natural source of vitamins A, B1, B2, C, D, and E. Contains minerals including Zinc, Calcium, and Potassium (Cohen 2019)
Pyropia tenera	Red Algae. Grows between 20-50 cm. Grows in a bush-like formation with crenulate edges. Found in the western Pacific Ocean and the Indian Ocean (FAO-FIGIS 2019)	Non-Toxic	Used for wrapping sushi rolls High in iodine Contains Vitamin C, Iron, Magnesium, Copper, Potassium Contains 10 times more Calcium than milk Supports thyroid function May reduce heart disease risk Promotes weight loss by delaying hunger Supports gut health (O'Brien 2018)
Saccharina japonica	Brown algae found in the northern hemisphere in temperate and cold waters. Grown on ropes in China and Japan Wave like edge (crenulate) Undivided frond Grows up to 4 meters (Robinson et al. 2013)	Non-Toxic	Used in Soups. Helps digestive health Natural source of vitamins A, B1, B2, C, D, and E. Contains minerals including Zinc, Calcium, and Potassium (Cohen 2019)

Ulva lactuca	Green Algae, margin is crenulate and torn. Has a mature height of 30 cm. no stipe. Disc-shaped (discoid) holdfast soft and translucent (Wells 2007)	Non-Toxic	anti-diabetic, antibacterial properties against E.coli and Staphylococcus, Improves skin condition through stimulating production and repair of collagen and elastin (Cohen 2019)
Caulerpa racemosa	Green Algae, trumpet-shaped () appendages surround the stipe. Has a mature height of 30 cm. can be branched or clumped together (De Kluijver et al.)	Non-Toxic	can lower risk for diabetes and promotes weight loss (O'Brien 2018)

Cited References

Cohen J. 2019. 14 amazing health benefits of kelp (seaweed) + side effects. Selfhacked. Available from: https://selfhacked.com/blog/kelp/

De Kluijver M, Gijswijt G, De Leon R, Da Cunda I. [date unknown]. Interactive Guide to Caribbean Diving. Available from: http://species-identification.org/species.php?species_group=caribbean_diving_guide&menuentry=soorten

Fisheries Global Information System (FAO-FIGIS). 2019. Fisheries Global Information System (FIGIS): FI Institutional Websites. In: FAO Fisheries and Aquaculture Department [online]. [Cited 27 March 2019]. Available from: http://www.fao.org/fishery/species/2790/en

Guiry MD. 2018. *Alexandrium tamarense* (Lebour) Balech. National University of Ireland: World Wide Electronic Publication. [updated 2002 Apr 26; cited 2018 Sept 3]. Available from: http://www.algaebase.org/search/species/detail/?species_id=40299

Jennings K. 2017. 9 impressive health benefits of chlorella. Healthline. Available from: https://www.healthline.com/nutrition/benefits-of-chlorella#section2

Jiang Y, Xiao P, Yu G, Sano T, Pan Q, Li R. 2012. Molecular basis and phylogenetic implications of deoxycylindrospermopsin biosynthesis in the cyanobacterium *Raphidiopsis curvata*. Appl Environ Microbiol 78:2256–2263. doi:10.1128/AEM.07321-11

Kipp RM. 2006. NOAA-Great Lakes Environmental Research Laboratory. [updated 2007 Feb 19; cited 2006]. Available from: https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/cylindro_factsheet.html

Kuwata A., Jewson DH. 2015. Ecology and Evolution of Marine Diatoms and Parmales. In: Ohtsuka S, Suzaki T, Horiguchi T, Suzuki N, Not F. editors. Marine Protists. Springer, Tokyo: Springer Japan. p. 251-275

Magaña HA, Contreras C, Villareal TA. 2003. A historical assessment of *Karenia brevis* in the western Gulf of Mexico. Harmful Algae. 2(3): 163-171. Available from: https://doi.org/10.1016/S1568-9883(03)00026-X

Masojídek J, Torzillo J. 2008. Mass Cultivation of Freshwater Microalgae. Encyclopedia of Ecology. p. 2226-2235. Available from: https://doi.org/10.1016/B978-0-12-409548-9.09373-8

Men'shova RV, Ermakova SP, Um BH, Zvyagintseva TN. 2013. The composition and structural characteristics of polysaccharides of the brown alga *Eisenia bicyclis*. Russ J Mar Biol. 39 (208): 208–213. Available from: https://doi.org/10.1134/S1063074013030103.

NCBI Taxonomy Browser. [date unknown]. Taxonomy Browser. Available from: https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Info&id=3077&lvl=3&lin=f&keep=1&srchmode=1&unlock

O'Brien S. 2018. 7 surprising health benefits of eating seaweed. Healthline. Available from: https://www.healthline.com/nutrition/benefits-of-seaweed

Ocean Data Center. [date unknown]. Phytoplankton identification. University of California Santa Cruz: CeNCOOS and HABMAP. Available from: http://oceandatacenter.ucsc.edu/PhytoGallery/toxigenic.html

Robinson N, Winberg P, Kirkendale L. 2013. Genetic improvement of macroalgae: status to date and needs for the future. Journal of applied phycology, 25 (3): 703-716. Available from: doi: 10.1007/s10811-012-9950-x

Wells E. 2007. Water Framework Directive – coastal water rocky shore monitoring: Field guide to British seaweeds. Environment Agency, Bristol. p. 25, 40, 59, 102, 107. Available from: http://magnusgaard.com/onewebmedia/EA%20Seaweed%20reference%20manual.pdf

Mission, Review Process & Disclaimer

The Association for Biology Laboratory Education (ABLE) was founded in 1979 to promote information exchange among university and college educators actively concerned with teaching biology in a laboratory setting. The focus of ABLE is to improve the undergraduate biology laboratory experience by promoting the development and dissemination of interesting, innovative, and reliable laboratory exercises. For more information about ABLE, please visit **http://www.ableweb.org/.**

Advances in Biology Laboratory Education is the peer-reviewed publication of the conference of the Association for Biology Laboratory Education. Published articles and extended abstracts are evaluated and selected by a committee prior to presentation at the conference, peer-reviewed by participants at the conference, and edited by members of the ABLE Editorial Board. Published abstracts are evaluated and selected by a committee prior to presentation at the conference.

Citing This Article

Andersen K, Bahl M, Mendoza P, Wright S, Ruffell SE 2019. An examination of algal morphology and toxicity through experiential learning. Article 21 In: McMahon K, editor. Advances in biology laboratory education.. Volume 40. Proceedings of the 41st Conference of the Association for Biology Laboratory Education (ABLE). https://doi.org/10.37590/able.v41.art21