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The Code in the Water: An Investigation into Harmful and Non-harmful Algal Blooms

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CODE IN THE WATER

AN INVESTIGATION INTO HARMFUL AND NON-HARMFUL ALGAL BLOOMS

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Grade Level
High School

Subject Area
Biology, Environmental, Marine Science

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Title: The Code in the Water: An Investigation into Harmful and Non-harmful Algal Blooms

Focus: Algal blooms can be detected using the DNA extracted from water samples. This activity allows students to identify algae and understand the causes of algal blooms.

Grade Level: High School Biology, Environmental or Marine Science

VA Science Standards:

BIO.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

a) observations of living organisms are recorded in the lab and in the field;
b) hypotheses are formulated based on direct observations and information from scientific literature;
c) variables are defined and investigations are designed to test hypotheses;
d) graphing and arithmetic calculations are used as tools in data analysis;
e) conclusions are formed based on recorded quantitative and qualitative data

BIO.5 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include

j) exploration of the impact of DNA technologies

BIO.8 The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include

a) interactions within and among populations including carrying capacities, limiting factors, and growth curves;
b) nutrient cycling with energy flow through ecosystems;
c) succession patterns in ecosystems;
d) the effects of natural events and human activities on ecosystems; and
e) analysis of the flora, fauna, and microorganisms of Virginia ecosystems.

Learning Objectives:

- Students will use simplified DNA "codes" to identify algal species present in a simulated water sample.
- Students will investigate what conditions lead to an algal bloom and what dictates a harmful algal bloom.
- Students will hypothesize why different environmental conditions contribute to changes in algal species type and concentration.
- Students will discuss the causes and impacts of algal blooms in coastal ecosystems.

Total length of time required for the lesson:
45 minutes to 1 hour, including time for the ending discussion

Key words/vocabulary:

***Algal bloom*:** A time of rapid algal growth leading to an increase in algal concentration to 1000 algal cells per mL of water or higher. Algal blooms are often accompanied by discoloration of the water.

Anoxia: When there is no oxygen present in a body of water, or a portion of a body of water.

Ciliate: Single celled organism characterized by the presence of cilia.

Cryptophyte: A single celled organism from the Phylum Cryptophyta.

Deoxyribose nucleic acid (DNA): The genetic code of an organism, often used to identify the organism.

Diatom: A single-celled organism with silicate cell walls.

Dinoflagellate: Single-celled organism characterized by the presence of two flagella.

Doubling time: The amount of time it takes for the algal population to double the number of cells present.

***Eutrophication*:** An increase in primary production in a system due to an increase in nutrient (generally either nitrate or phosphate) availability.

Gel electrophoresis: A method used to visualize DNA by running DNA fragments on an agarose gel using electricity. Shorter fragments move further down the gel than longer fragments.

Genuses: an alternate accepted plural form of genus, can be used in place of genera.

Harmful algal bloom: An algal bloom dominated by a toxic species or an algal bloom that negatively effects the health of other organisms in the ecosystem.

Hypoxia: When the oxygen present in a body of water, or a portion of a body of water, is low, dropping below 3 mg/L.

Remineralization: the process in which microbes break down organic matter into its base components, i.e. CO_2; also known as respiration.

Residence time: The length of time for a parcel of water to move entirely through a river or estuary.

Quantitative polymerase chain reaction (qPCR): A molecular technique in which the number of gene copies of a specific gene in a sample can be counted through the use of specific primers paired with a fluorescence.

Background Information:

Algal Species Selection: Algae, also known as phytoplankton, are present year-round in coastal and estuarine systems. The types of algae present in any given season is largely determined by environmental conditions during different seasons since many algae have temperature and salinity ranges in which they best grow and survive. The availability of nutrients, including nitrate, phosphorous, and silicate, can also determine which algal species are present in a system. For example, diatoms require high levels of silicate, nitrate, and phosphorous and when sufficient levels of nutrients are present, can out compete other algal groups including dinoflagellates. Dinoflagellates on the other hand, can out compete diatoms and other algal groups when nutrients are low to moderate.

Algal Blooms and Harmful Algal Blooms: Algal blooms occur when conditions allow one or more algal species to grow very quickly, reaching 1000 cells per mL or higher. For an algal bloom to occur, there needs to be sufficient nutrients and an appropriate temperature, salinity, and light availability for the organism that is blooming. Additionally, the doubling time of the organism needs to be less than the residence time of the body of water. Low concentrations of algal predators and diseases are also helpful if a bloom is to become established. Algal blooms are natural and have always been present in coastal systems; however, there has been an increase in algal blooms and harmful algal blooms in particular over the past decades. This increase has been associated with eutrophication in many systems. Harmful algal blooms are blooms of algae that are harmful because they produce a toxin or otherwise negatively impact other organisms. Some blooms of non-toxic algae have been categorized as harmful based on their negative effects to the ecosystem (see the next section).

Impacts of Algal Blooms: Algal blooms lead to huge surges in primary production. This increased primary production leads to an increase in biomass. As the algae die, the new biomass sinks to the bottom water and the sediments where bacteria remineralize or respire it. This consumes available oxygen and can lead to hypoxia or anoxia, especially in summer when warm water and high stratification lead to poor water column mixing. Anoxia and hypoxia can lead to fish kills and the death of other organisms. Additionally, large algal blooms generally shade the benthic system leading to the death of seagrasses and other benthic vegetation. If the algal bloom in question is produced by a harmful or toxic algae then the effects of the algal bloom may be even more detrimental with an increase in the deaths of other organism and, potentially, an impact on the health of humans that eat seafood collected during the harmful algal bloom.

Materials & Supplies:

- Background information slides can be found in the accompanying PowerPoint.
- The Algal Info Sheet, including the DNA code gels can be found at the end of the lesson plan.
- 4 Student Worksheets, one for each seasonal sample, can be found at the end of the lesson plan along with accompanying answer keys.
- Class discussion questions can be found in the accompanying PowerPoint.
- Water samples: Water samples with their DNA gels can be printed out on a sheet of paper and distributed to students. These samples can be found at the end of the lesson plan.

Teacher Preparation:

Teachers need to prepare the water samples by printing out a water sample sheet for each group/student. In addition to their water sample, each group will need the corresponding student worksheet and an Algal Info Sheet.

Classroom Setup:

The classroom setup will be dependent on the number of groups participating in the activity.

Procedure:

1. Review the needed background information with the class. Background slides have been provided that can be used to assist in this.
2. Split the class into groups. There are 4 water samples, but multiple groups can have the same water sample (replicates) depending on the size of the class and the number of students you would like in each group.
3. Distribute an Algal Info Sheet, water sample, and appropriate student worksheet to each group. Please ensure that all water samples are represented by at least one student group so the entire seasonal change of algae in Algal Bay is represented.
4. Students should complete the entire worksheet and answer all questions.
5. Once all groups have completed the worksheet, the post-activity discussion can take place. This is a chance to discuss how environmental characteristics can affect the appearance of a bloom, as well as the specific organisms that are present at different times of year and under different environmental conditions. Additionally, there is an opportunity to discuss the difference between harmful and non-harmful algal blooms, the impacts algal blooms can have on an ecosystem, and the increasing prevalence of harmful and non-harmful algal blooms in connection with eutrophication and increased nutrient runoff into coastal systems. Slides to encourage discussion on these topics have been included in the accompanying PowerPoint, but slides can be added or taken away to ensure the lesson plan fulfills all discussion topics needed.

Assessment:

Included in the lesson plan is a worksheet for students to complete. Assessments can be made based on the worksheet and participation in the post activity discussion.

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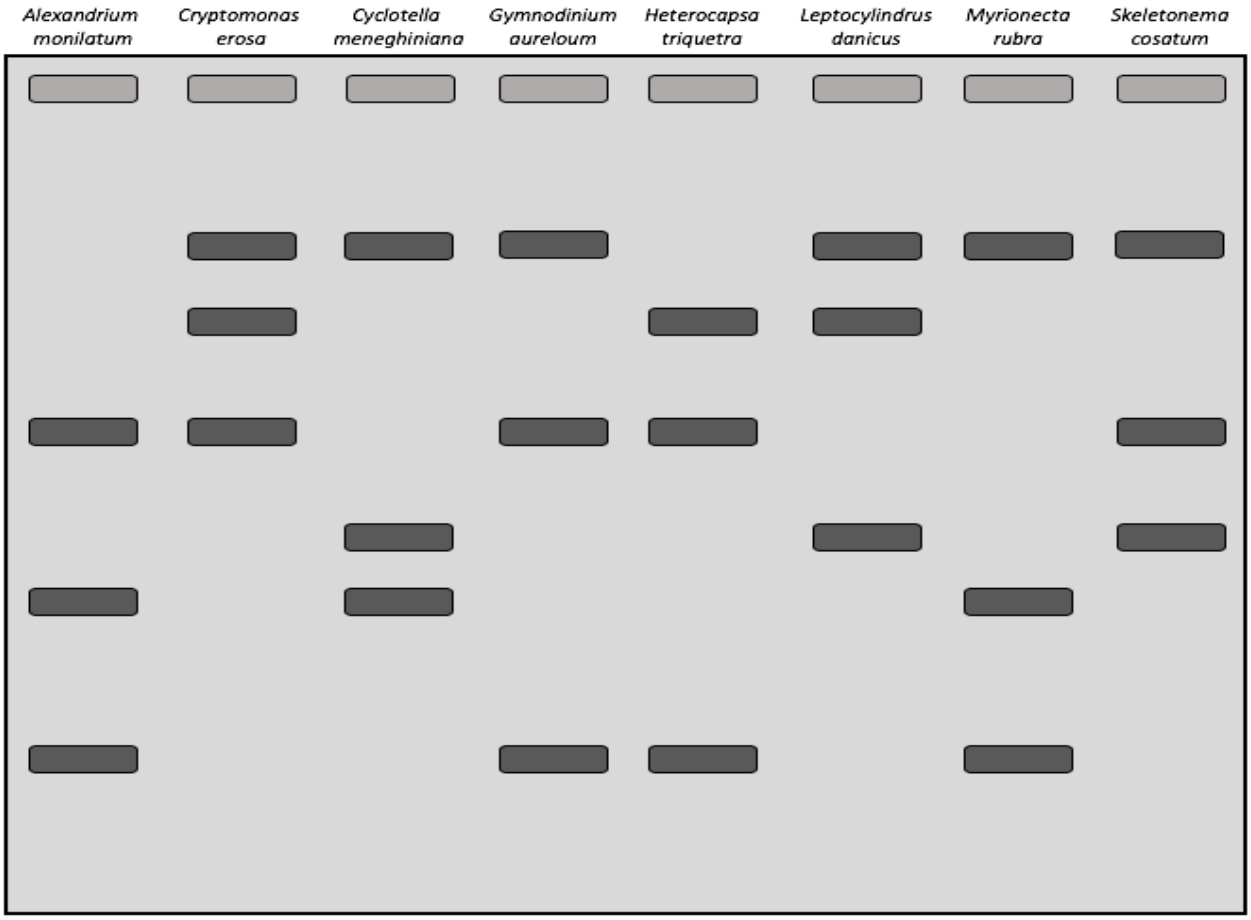
Algal Info Sheet



Alexandrium monilatum is an armored dinoflagellate found along the east coast of the US and in the Gulf of Mexico. *A. monilatum* cells often form chains that swim through the water. This species produces a toxin called goniodomin A that has been found to harm fish, oysters, and other organisms.
A. monilatum grows best at high temperatures and high salinities. It can survive with lower nutrient levels than some other species.

Cryptomonas erosa is a cryptophyte common in temperate waters. It is not known to be harmful to other organisms and, due to its ability to withstand low temperatures and variable salinity and nutrient ranges, it can be found year-round in many habitats.

Cyclotella meneghiniana is a centric diatom that is normally found as a single cell, not connected to others in chains. This species is not known to be harmful, and is found in nutrient rich waters in shallow, coastal habitats.

Gymnodinium aureloum is an unarmored dinoflagellate found in coastal waters around the world. It has not been found to be harmful to fish or other organisms. This species can survive low nutrient conditions and grows well in moderate salinity and warm waters.

Heterocapsa triquetra is a dinoflagellate that does not form chains. It is not known to have harmful effects on other organisms or to produce a toxin. This species prefers warm temperatures, and low salinities. It can survive at a range of nutrient levels.

Leptocylindrus danicus is a diatom that is usually found in chains. This species is not known to be harmful to any organisms and prefers a warm climate and coastal waters. *L. danicus* is generally found in waters with high levels of phosphorus.

Myrionecta rubra is a ciliate with no known harmful effects. It is present year-round and can handle a wide range of salinities and nutrient levels. It can also survive and withstand cold temperatures.

Skeletonema cosatum is a cylindrical shaped, centric, photosynthetic diatom. It usually forms chains, and has not been found to be harmful in most ecosystems. *S. cosatum* has been found around the world in coastal waters where it prefers high light levels and high levels of nitrate. This species grows best when nutrients are in high concentrations.

Student Worksheet
December Sample

Instructions:

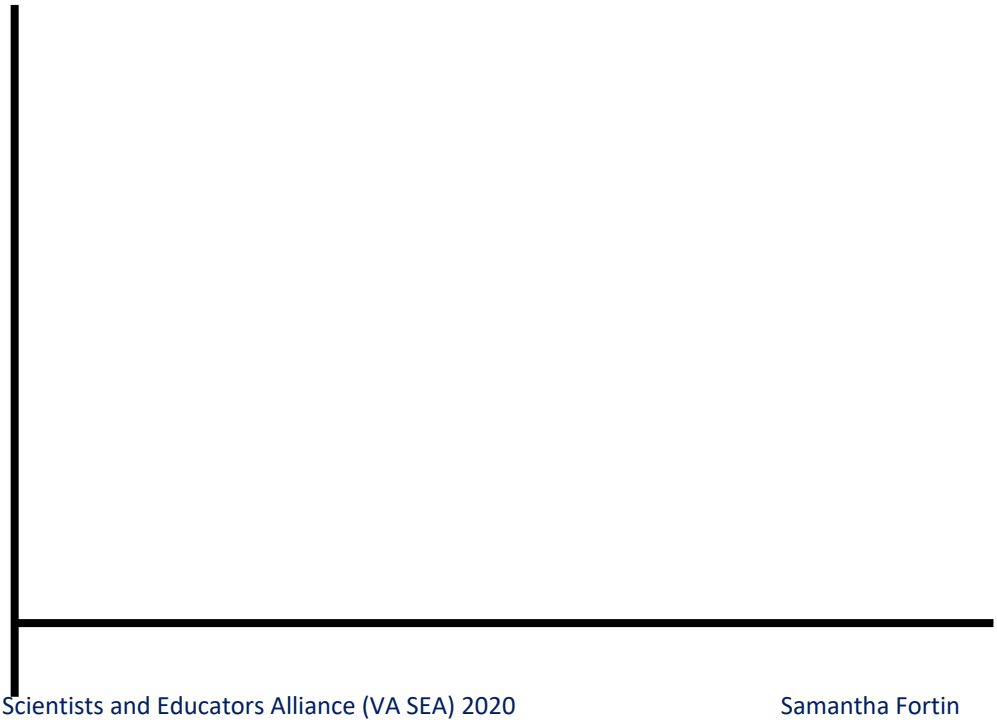
You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have: extracted the algal DNA from a small portion of your water sample; and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the Algal Info sheet, identify the genus of each type of algal cells present in your sample. Count the number of each algal cell and **multiply that number by 10** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	Number of cells per mL	Algal category

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.



2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

6. December in Algal Bay is characterized by cold waters, high salinities, and low nutrient concentrations. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose one hypothesis on why you have, or do not have a bloom, and why the species present in your sample are common in December.

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not. Use your hypothesis from question 7 to help in the discussion.

Student Worksheet—Answer Key
December Sample

Instructions:

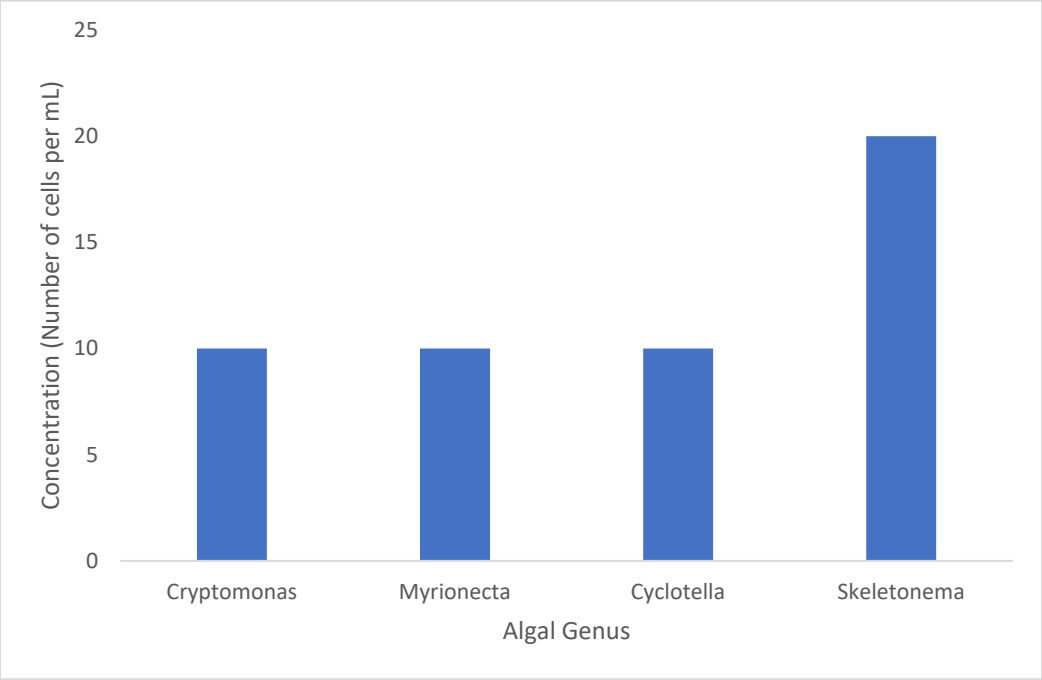
You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have extracted the algal DNA from a small portion of your water sample and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the algal info sheet, identify the genus of each of your algal cells. Count the number of each algal cell and **multiply that number by 10** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	**Number of cells per mL**	**Algal category**
Cryptomonas	10	Cryptophyte
Myrionecta	10	Ciliate
Cyclotella	10	Diatom
Skeletonema	20	Diatom

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.



2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

Skeletonema

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

No, none of the genuses are harmful.
Filter feeders, like oysters, would be the first to be impacted by harmful algal blooms.
Humans can be impacted by closures of shellfish beds (impacting recreational and commercial fisheries), closures of beaches for swimming and other water sports, and by consuming contaminated shellfish which can cause paralytic, diuretic, and neurotoxic shellfish poisoning, depending on the toxin produced by the harmful algae.

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

50

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

No. Algal blooms require sufficiently high concentrations of nutrients to enable exponential growth and a high enough temperature to encourage the blooming species to grow and survive.

6. December in Algal Bay is characterized by cold waters, high salinities, and low nutrient concentrations. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose one hypothesis on why you have, or do not have a bloom, and why the species present in your sample are common in December.

Possible hypotheses include:

- All species present can survive in cold waters with moderate nutrient concentrations.
- The moderate nutrients and cold waters are not good conditions for bloom development.

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not. Use your hypothesis from question 7 to help in the discussion.

Student Worksheet
March Sample

Instructions:

You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have extracted the algal DNA from a small portion of your water sample and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the algal info sheet, identify the genus of each of your algal cells. Count the number of each algal cell and **multiply that number by 200** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	Number of cells per mL	Algal category

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.

2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

6. March in Algal Bay is characterized by moderate temperature waters, moderate salinities, and high nutrient concentrations from increased precipitation. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose one hypothesis on why you have, or do not have a bloom, and why the species present in your sample are common in March.

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not. Use your hypothesis from question 7 to help in the discussion.

Student Worksheet—Answer Key
March Sample

Instructions:

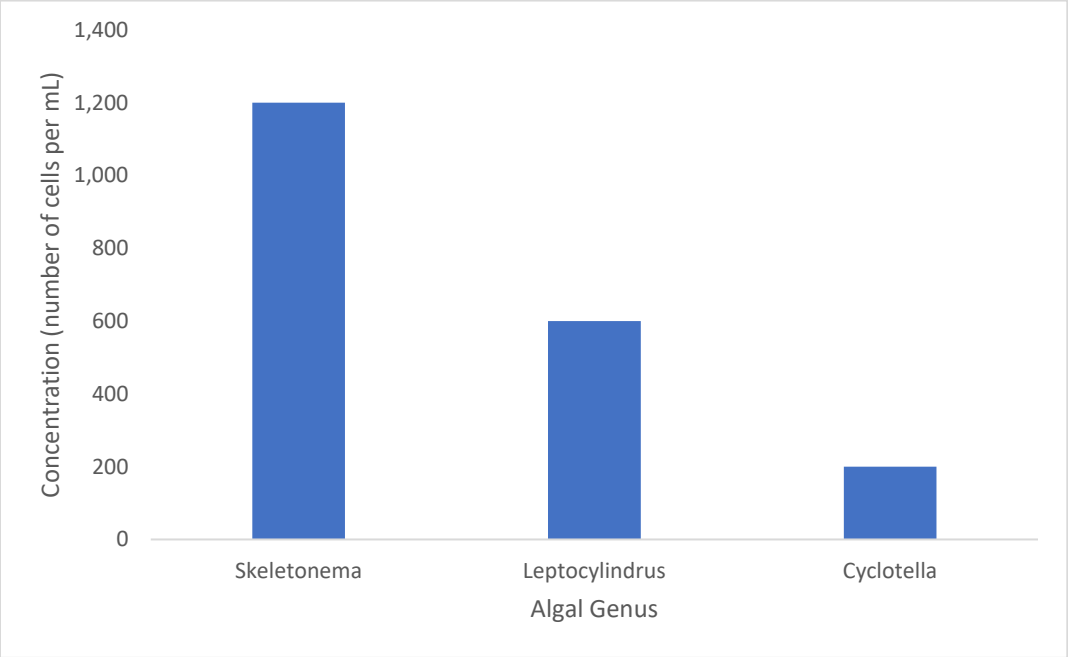
You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have extracted the algal DNA from a small portion of your water sample and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the algal info sheet, identify the genus of each of your algal cells. Count the number of each algal cell and **multiply that number by 200** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	Number of cells per mL	Algal category
Skeletonema	1,200	Diatom
Leptocylindrus	600	Diatom
Cyclotella	200	Diatom

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.



2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

Skeletonema

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

No, none of the genuses are harmful.
Filter feeders, like oysters would be the first to be impacted by harmful algal blooms.
Humans can be impacted by closures of shellfish beds (impacting recreational and commercial fisheries), closures of beaches for swimming and other water sports, and by consuming contaminated shellfish which can cause paralytic, diuretic, and neurotoxic shellfish poisoning, depending on the toxin produced by the harmful algae.

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

2,000

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

Yes. Algal blooms require sufficiently high concentrations of nutrients to enable exponential growth and a high enough temperature to encourage the blooming species to grow and survive.

6. March in Algal Bay is characterized by moderate temperature waters, moderate salinities, and high nutrient concentrations from increased precipitation. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose one hypothesis on why you have, or do not have a bloom, and why the species present in your sample are common in March.

Possible hypotheses include:

- High nutrient conditions encourage bloom conditions.
- Diatoms do best in high nutrient conditions, outcompeting dinoflagellates and other algae.
- Diatoms can survive in moderate temperatures and salinities.

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not. Use your hypothesis from question 7 to help in the discussion.

Student Worksheet
August Sample

Instructions:

You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have extracted the algal DNA from a small portion of your water sample and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the algal info sheet, identify the genus of each of your algal cells. Count the number of each algal cell and **multiply that number by 1000** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	Number of cells per mL	Algal category

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.

2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

6. August in Algal Bay is characterized by very warm waters, high salinities, and moderate nutrient concentrations. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose two hypotheses on why you have, or do not have a bloom, and why the species present in your sample are common in August.

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not. Use your hypothesis from question 7 to help in the discussion.

Student Worksheet—Answer Key
August Sample

Instructions:

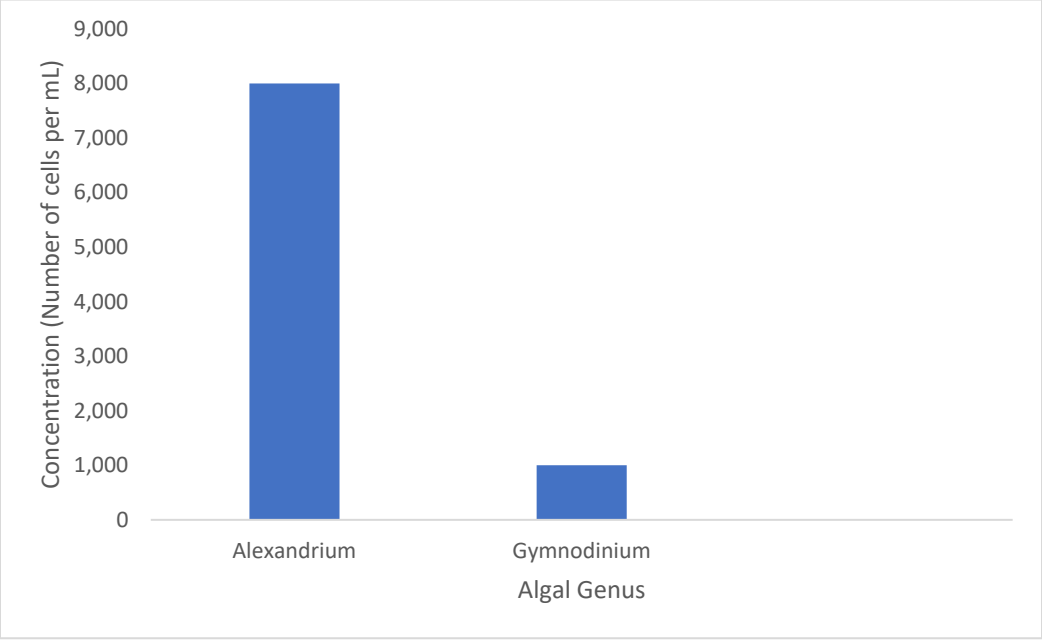
You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have extracted the algal DNA from a small portion of your water sample and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the algal info sheet, identify the genus of each of your algal cells. Count the number of each algal cell and **multiply that number by 1000** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	Number of cells per mL	Algal category
Alexandrium	8,000	Dinoflagellate
Gymnodinium	1,000	Dinoflagellate

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.



2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

Alexandrium

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

Yes, *Alexandrium monilatum.*
Filter feeders, like oysters would be the first to be impacted by harmful algal blooms.
Humans can be impacted by closures of shellfish beds (impacting recreational and commercial fisheries), closures of beaches for swimming and other water sports, and by consuming contaminated shellfish which can cause paralytic, diuretic, and neurotoxic shellfish poisoning, depending on the toxin produced by the harmful algae.

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

9,000

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

Yes. Algal blooms require sufficiently high concentrations of nutrients to enable exponential growth and a high enough temperature to encourage the blooming species to grow and survive.

6. August in Algal Bay is characterized by very warm waters, high salinities, and moderate nutrient concentrations. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose two hypotheses on why you have, or do not have a bloom, and why the species present in your sample are common in August.

Possible hypotheses include:

- Warm water temperatures select for *Alexandrium* growth.
- High salinities select for *Alexandrium* growth.
- Moderate salinities select for dinoflagellate growth over diatoms and other algal types.

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not. Use your hypotheses from question 7 to aid in the discussion.

Student Worksheet
October Sample

Instructions:

You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have extracted the algal DNA from a small portion of your water sample and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the algal info sheet, identify the genus of each of your algal cells. Count the number of each algal cell and **multiply that number by 100** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	Number of cells per mL	Algal category

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.

2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

6. October in Algal Bay is characterized by warm waters, high salinities, and moderate nutrient concentrations. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose one hypothesis on why you have, or do not have a bloom, and why the species present in your sample are common in October.

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not.

Student Worksheet—Answer Key
October Sample

Instructions:

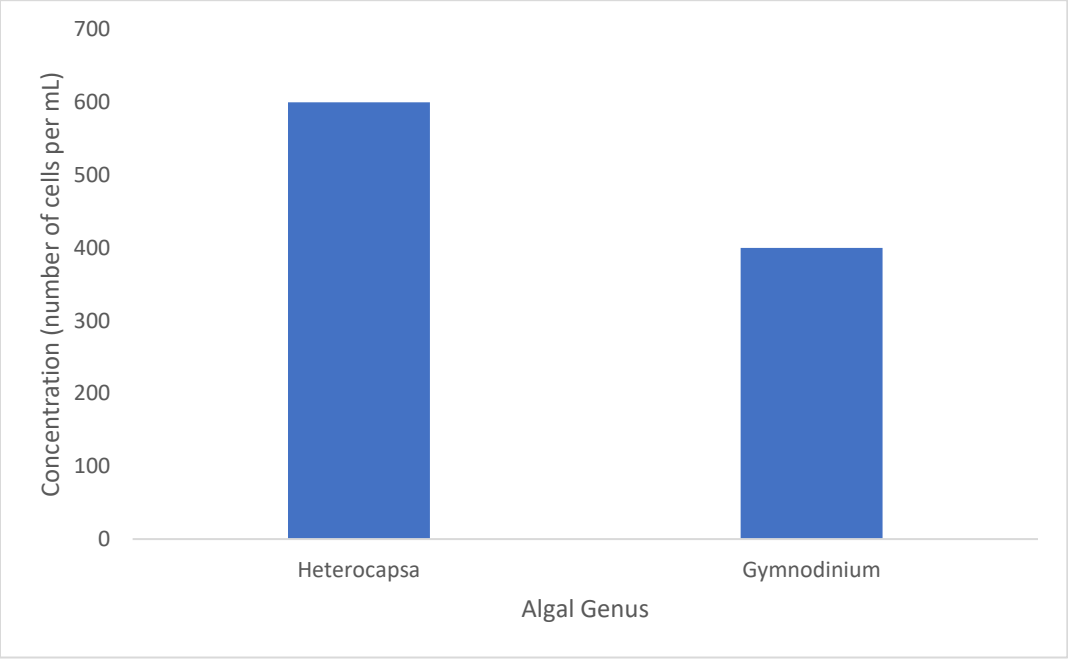
You are a scientist studying algae. People are concerned that there are harmful algal blooms forming in Algal Bay. You have collected a water sample as part of a monitoring program and it is your job to determine what type of algae are present in the water. Additionally, you need to decide if there is a bloom of algae, and if the algae present in the water make the bloom a harmful algae bloom.

To do this, you have extracted the algal DNA from a small portion of your water sample and used quantitative PCR to determine which algal cells are present and how many there are.

Using the DNA visualized on a gel for each organism and the algal info sheet, identify the genus of each of your algal cells. Count the number of each algal cell and **multiply that number by 100** to calculate how many algal cells are present in 1 mL of Algal Bay water**.** Record the types and numbers of algal cells you observe in your sample in the table below then answer all questions on this worksheet.

Algal genus	Number of cells per mL	Algal category
Heterocapsa	600	Dinoflagellate
Gymnodinium	400	Dinoflagellate

1. Using the x and y axes below, create a bar graph representing the genuses (genera) of algae present in your sample and their concentrations in number of cells per mL. Please ensure that your axes are labeled and have an appropriate scale for the concentration axis.



2. What is the dominant algal genus in your sample? Based on the algal info sheet, determine what algal category (diatom, dinoflagellate, cryptophyte, or ciliate) each of your algal genuses (genera) belongs to and record that information in the table.

Heterocapsa

3. Are any of your algal genuses (genera) harmful algae? If so, which ones? What organisms would be the first to be impacted by harmful algal blooms? How are humans impacted by harmful algal blooms?

No.
Filter feeders, like oysters would be the first to be impacted by harmful algal blooms.
Humans can be impacted by closures of shellfish beds (impacting recreational and commercial fisheries), closures of beaches for swimming and other water sports, and by consuming contaminated shellfish which can cause paralytic, diuretic, and neurotoxic shellfish poisoning, depending on the toxin produced by the harmful algae.

4. Add up the number of cells per mL from each algal genus to determine the total number of algal cells present in your sample.

1,000

5. An algal bloom can occur when the total number of algal cells reaches or surpasses 1000 cells per mL. Based on this definition, does your sample reflect an algal bloom? What sort of conditions are necessary to support an algal bloom?

Yes. Algal blooms require sufficiently high concentrations of nutrients to enable exponential growth and a high enough temperature to encourage the blooming species to grow and survive.

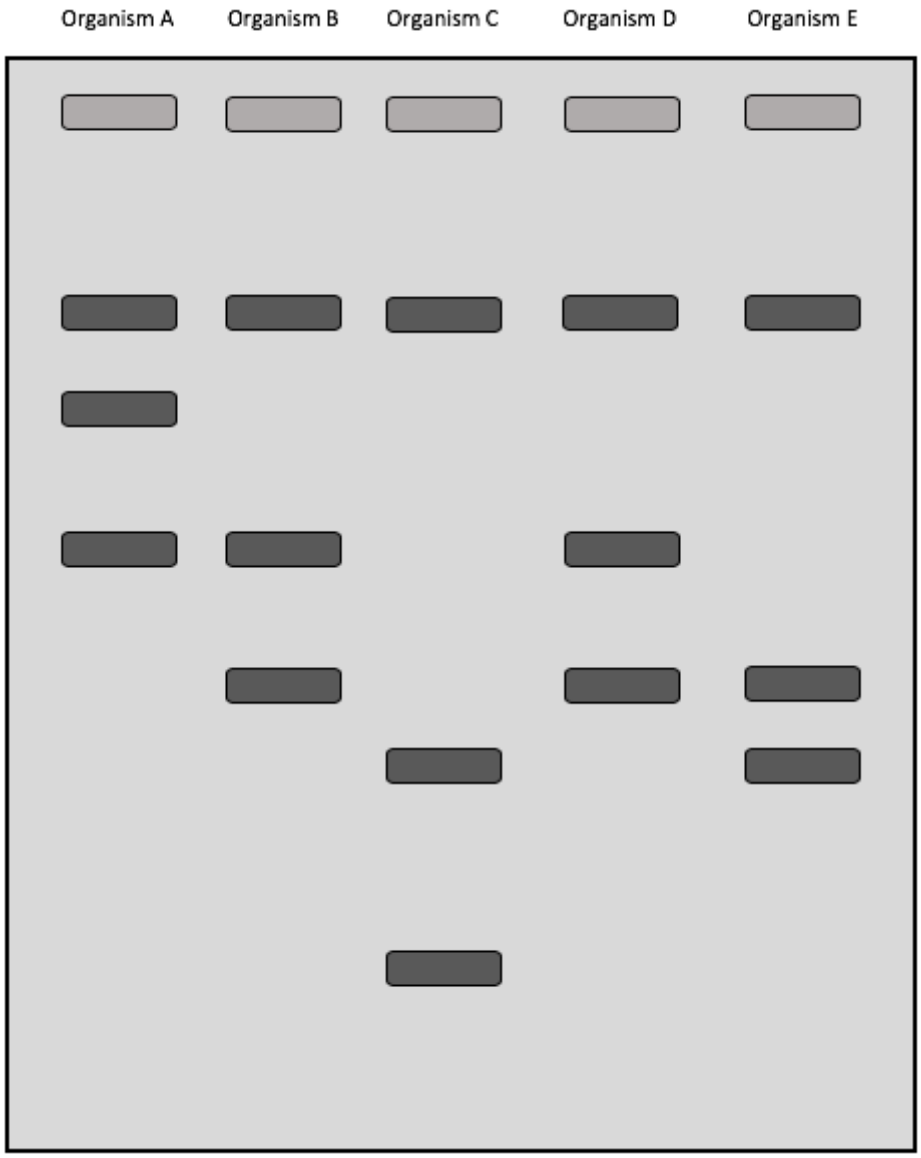
6. October in Algal Bay is characterized by warm waters, high salinities, and moderate nutrient concentrations. Based on this, and the knowledge you have gained from the Algal Info Sheet, propose one hypothesis on why you have, or do not have a bloom, and why the species present in your sample are common in October.

Possible hypotheses include:

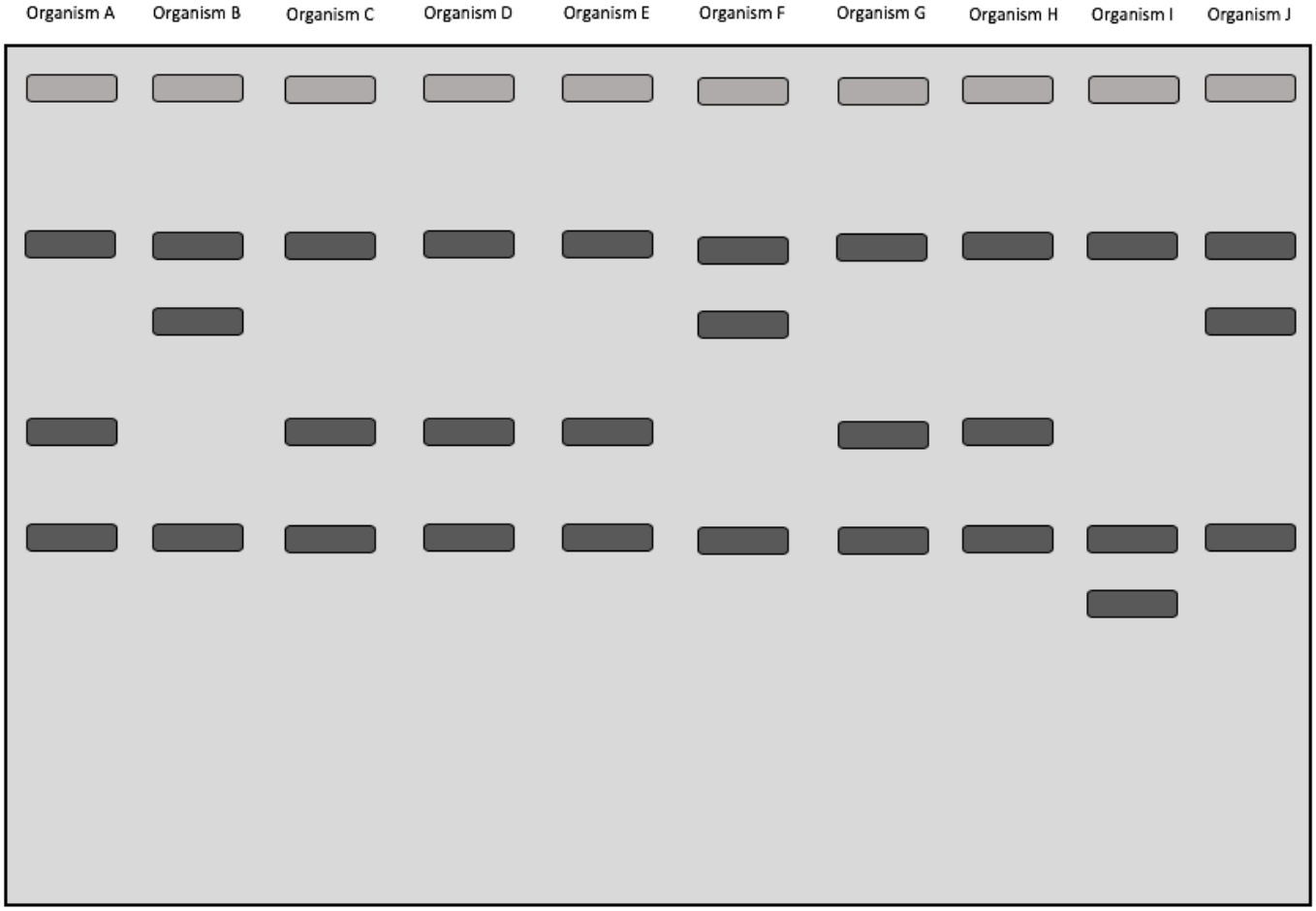
- Warm waters with high salinity and moderate nutrients select for dinoflagellates (this can be broken up into multiple hypotheses)
- Warm water with moderate levels of nutrients are good conditions for blooms to occur

When asked, make a short report to the rest of your class describing the types and concentrations of algae present in your sample, as well as if there is or is not an algal bloom or a harmful algal bloom present in Algal Bay during your season. As a class, you will discuss why some seasons have blooms and others do not.

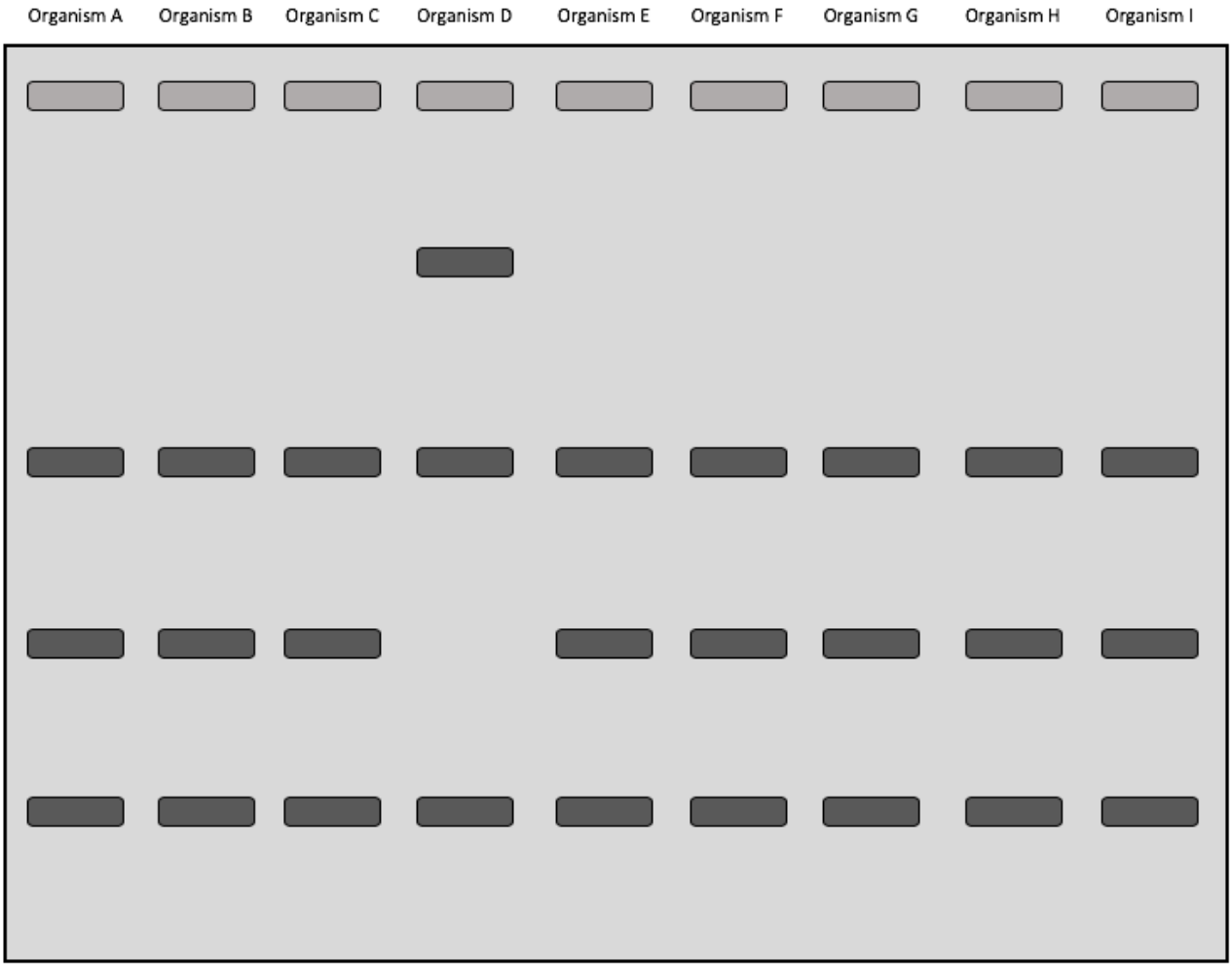
December Water Sample



March Water Sample



August Water Sample



October Water Sample