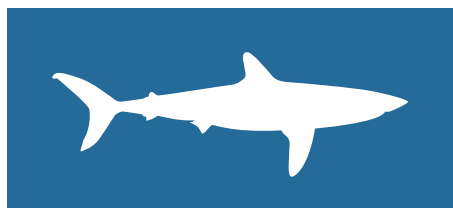


DISCOVER THE BAY



CLASSROOM ACTIVITY GUIDE

THEME:

The San Francisco Bay and its watershed are diverse and complex ecosystems, whose health depends on our everyday actions.

CRITICAL ISSUE:

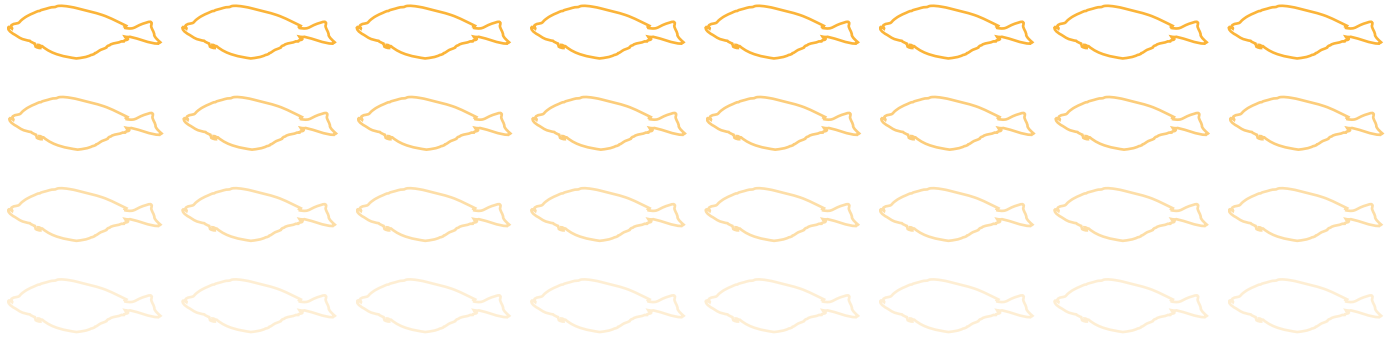
Climate Change, Freshwater Flows

CONTENTS:

Activity #1: Hybrid and Alternative Energy Sources	3
Activity #2: All About Plankton	11
Activity #3: Water, Water Everywhere	18
Activity #4: Our Waters and Us.	23
Activity #5: Observation	27



a division of **bay.org**



MISSION STATEMENT:

Aquarium of the Bay's Education and Conservation Department's mission is to promote literacy in ocean and watershed health, climate change issues, and science career development through the lens of critical issues such as sustainable seafood, marine protected areas, marine debris and plastics, climate change and fresh water flows.

ACKNOWLEDGEMENTS:

Aquarium of the Bay thanks Alcatraz Cruises, S.D. Bechtel, Jr. Foundation, the John and Marcia Goldman Foundation, and an anonymous donor for their generous support of Discover the Bay Hybrid Ferry program and development of this Teacher Resource Guide.



HYBRID AND ALTERNATIVE ENERGY SOURCES

ACTIVITY 1

Enduring Understanding: We have the power to make choices in our everyday lives that either contribute to global climate change or help mitigate it.

Materials

- “A Green Day” pictures sheet
- Index cards (optional)
- Envelopes
- Water source
- Enough of these materials to have a set for each small group:
 - Flask
 - Two Alka-Seltzer tablets
 - Plastic tubing (or flexible straws)
 - Two thermometers
 - Lamp (any kind as long as the bulb emits heat)
 - Two containers that comfortably fit a piece of charcoal
 - Charcoal
 - Rubber band

SETUP:

1. Make enough copies of “A Green Day” pictures sheets so that there can be a set of pictures for each small group.
2. Cut out the words and pictures and paste them onto blank index cards.
3. Fill each envelope with a complete set of “A Green Day” index cards so that there is one set per small group.
4. For the Greenhouse Effect Experiment, plug in and set up the lamps you have available so that either each small group has their own, or can share with another group to place their beakers underneath the heat.
5. Also, if necessary, cut the plastic tubing into smaller sections so that each group has a tube that is about one foot in length.

PROGRAM OUTLINE:

Introduction:

- Begin by dividing the students into small groups and having them discuss the following questions on climate change.
 - What is climate change?
 - How does it impact the planet?
 - How do humans impact climate change?
 - What can we do every day to make a positive change?
- Then, gather together as a class and have the students share some of answers they came up with for each question. You could create a list on the chalk or white board of the positive and negative ways that we impact climate change.
- Next, explain the difference between renewable and non-renewable energy sources.
 - Non-renewable energy, which is produced from resources that take millions of years to be recreated such as fossil fuels, is not sustainable.
 - Renewable energy: Energy that comes from resources that

PROGRAM OUTLINE CONTINUED:

are easily replenished on a human timescale such as solar energy, wind energy, and hydroelectric power.

- How have humans used innovations in renewable energy sources to have a positive impact on climate change?

“A Green Day”

- Many of the things we do and decisions we make in our everyday lives have an impact on the planet. Some of them contribute to global climate change, while others have small impacts or actually help mitigate climate change.
- Divide the students back into their small groups or mix it up and create new small groups.
 - Give each group an envelope with everyday human actions and behaviors.
 - By lying the cards out on the floor or table, have the students create a “green” daily routine and a “not-so-green” day.
 - You can also have a few blank or wild cards so they can create a few of their own everyday actions for either day’s routine.
 - What are some of the activities in the green day that they already do?
 - What are some ways they could change their routine to make it more ‘green’ and contribute less to global climate change?
 - What are some ways communities of people can work together to have a positive impact?
- Come back together and discuss which activities the students put in each day.
- Have the student share some of their answers to the previous questions.

Greenhouse Effect Experiment

- Now, the students are going to explore how exactly humans’ actions cause climate change by intensifying the Greenhouse Effect of the earth’s atmosphere.
- Divide the class into small groups and have each group collect a set of the materials listed above.
- Have the groups place a charcoal brick in each of the two containers.
 - One container is going to represent an Earth without human impacts, and the other will represent today’s Earth where humans’ actions are causing carbon emissions.
- Have the students begin by putting a thermometer in each container and placing the containers both directly under a heat lamp, trying to keep them evenly exposed to the light/heat.
- After allowing the containers to adjust to this new temperature (~10 minutes), have the students take a temperature reading on the thermometers for both Earths—we want to make sure that both Earths are approximately the same temperature to begin with (when conditions are the same).
- Next, the students can fill their flask 1/3 of the way full with water, add the two Alka-Seltzer tablets, and then insert their plastic tubing into the opening of the flask. The other end of the plastic tubing should be inserted into one of the two containers—this container is now the earth with human-caused, or anthropogenic, pollution.
 - The Alka-Seltzer and water creates a chemical reaction that produces carbon dioxide. As that carbon dioxide is pumped into the earth’s atmosphere, more of the heat from the ‘sun’ will be trapped underneath the atmosphere as the ‘blanket’ radiates heat back towards the earth’s surface.
- Finally, have the students take another temperature reading to compare the two Earths’ climates, once one has been impacted by humans’ actions such as excessive energy consumption and the subsequent releasing of more greenhouse gases into the earth’s atmosphere.

PROGRAM OUTLINE CONTINUED:

- The container with the extra CO₂ should start to heat up in comparison to the container that isn't connected to the flask. When done successfully, the human-impacted Earth's temperature will rise up to 4 degrees! Even though this may seem small, changes like this can have a huge impact on the planet's ecosystems and natural processes (see instructor background for more details).

Wrap Up Discussion

- What did the students see happening in both of their Earth environments?
- Why might the human-impacts Earth be heating up compared to the Earth with no impacts?
- Finally, review some of the best ways they can try to help minimize humans' negative impact on the earth's atmosphere. Allow students to be creative. Include a discussion of bigger community solutions that people could work on together to make a difference.



TEACHER BACKGROUND:

Global climate change is a worldwide phenomenon of longstanding weather patterns changing from historical norms that is caused by an increase in the average global temperature. Natural causes and human activities can contribute to this increase. Scientific research and evidence support the hypothesis that current climate change is occurring largely due to human activities. When people burn fossil fuels, the carbon that was stored as coal or oil for millions of years is released in the form of carbon dioxide. That carbon dioxide adds to the earth's atmosphere which holds in the sun's heat, acting like a heat trapping blanket. When excess carbon dioxide is emitted and added to the atmosphere, that blanket becomes much thicker, and the planet holds in too much heat.

Even small changes in temperature have a large effect on planet Earth. Just a 2°C (3.6°F) increase can have impacts around the world on biodiversity, agriculture, ocean ecosystems, and much more. These impacts include more extreme weather events—such as super-storms, more intense hurricanes, increased droughts—and an increase in sea level. These changes can harm Earth's ecosystems in a number of ways. Since changes are happening more rapidly than most naturally-occurring climactic changes, it is difficult for ecosystems to adapt naturally.

One way we can slow down the global increase in temperature is by using alternative energy sources. Since the U.S. accounts for approximately 20% of global emissions and some 40% of industrialized country emissions, a large difference can be made by Americans working together to implement renewable energies. By harvesting energy from renewable resources, like the sun or the wind instead of fossil fuels and natural gas, carbon dioxide emissions will decrease, thus mitigating climate change.



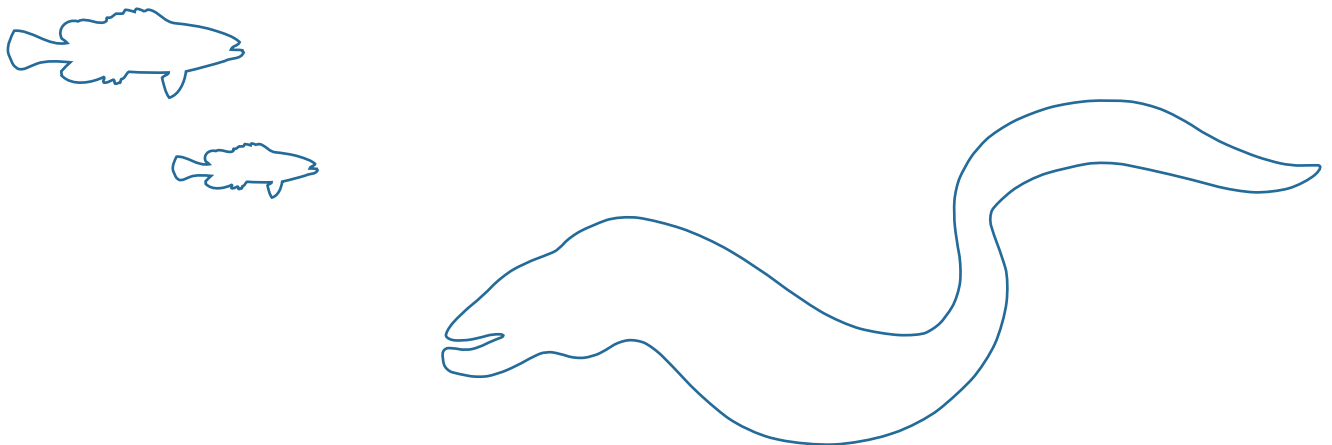
GLOSSARY:

Atmosphere: A layer of gases naturally surrounding our planet that acts as a blanket, making Earth comfortable for living things. We depend on the atmosphere to hold in heat from the sun, provide air for us to breathe, and protect the Earth's surface from meteors and asteroids.

Greenhouse Effect: Certain gases in the atmosphere trap radiation from the sun making the earth's surface warmer, in the same way that a greenhouse keeps the inside temperature warmer.

Renewable energy: Energy that comes from resources that are easily replenished on a human timescale such as solar energy, wind energy, and hydroelectric power.

Non-renewable energy: Energy produced from resources that take millions of years to be recreated and are, therefore, not sustainable. For example, energy derived from the burning of fossil fuels such as natural gas, coal, petroleum, etc.



STANDARDS:

California Science Standards:

Fifth Grade

- 6.f. Select appropriate tools (e.g., thermometers, meter sticks, balances, and graduated cylinders) and make quantitative observations.

Sixth Grade

- 4.b. Students know solar energy reaches Earth through radiation, mostly in the form of visible light.
- 6.a. Students know the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process.
- 6.b. Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.

Seventh Grade

- 7.d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

California Next Generation Science Standards:

Fifth Grade

- 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. [Clarification Statement: The geosphere, hydrosphere (including ice), atmosphere, and biosphere are each a system and each system is a part of the whole Earth System. Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere.]
 - Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.
- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the earth's resources and environment.
 - Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

Middle School

- MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but

STANDARDS CONTINUED:

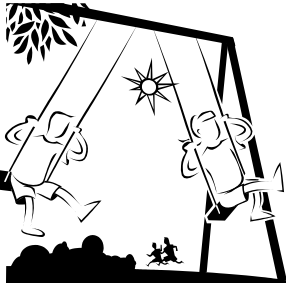
are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.
- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]
 - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]
- MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]
 - Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.
- MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

Name: _____

Date: _____

"A GREEN DAY" PICTURES



SAFEWAY 



ACTIVITY 2

ALL ABOUT PLANKTON

Enduring Understanding: Plankton are a diverse and important part of the local and global food web.

Materials

- Edible seaweed—found at many supermarkets (optional)
- “Design Your Own Plankton” handout
- Drawing utensils (i.e. markers, crayons, colored pencils, etc.)
- A variety of things that float: corks, straws, packing peanuts, etc.
- A variety of things that sink: pipe cleaners, metal washers, paper clips, etc.
- A water source
- A deep, clear bucket or pitcher

SETUP:

1. Make copies of the “Design Your Own Plankton” handout, one per student.
2. Choose a location for the Plankton “Race”—a space that can get wet or be easily dried or wiped up afterward is ideal.
3. Fill the bucket or pitcher with tap water.

PROGRAM OUTLINE:

Introduction

- What are plankton?
- Phytoplankton vs. zooplankton
- Holoplankton vs. meroplankton

Design Your Own Plankton

- Plankton are an extremely diverse group of plants and animals that have a variety of adaptations for survival.
- Have the students brainstorm with a small group to create different types of imaginary plankton with real adaptations and draw them on the “Design Your Own Plankton” worksheets.
- Next, the students should try to explain how the types of plankton they created would interact with each other. Would they make their own energy or eat one another? Would they stay in groups?
- And finally, they can try to speculate how their plankton might actually fit into a larger food web.
 - Plankton are crucial to the survival of almost every other organism in the Bay, as well as surrounding terrestrial animals, since they are the base of the food web. Phytoplankton produce at least 50% of the world’s oxygen.

PROGRAM OUTLINE CONTINUED:

Plankton “Race”

- Plankton are drifters. Phytoplankton need sunlight to survive, and zooplankton need food. The ideal place for plankton to live is in the middle of the water column, not the very surface or the bottom.
- Why might plankton prefer to live in the middle of the water column rather than at the surface or bottom?
 - Phytoplankton (the plant-like plankton) need carbon dioxide and sunlight to survive, which can't be found at the bottom. However, if the plankton stay too close to the surface they will receive too much UV light and get tossed around by the wave action at the surface.
 - Zooplankton eat phytoplankton and each other, and therefore need to be where the food is in the middle.
 - Since plankton cannot swim against a current and can barely choose a direction to move, in order to change their place in the water they must change their buoyancy or density. They can do this by ingesting air, linking up with or breaking away from other plankton, or by increasing or decreasing their surface area to body size ratio by growing spikes, hairs, or 'tails'.
- The students' goal is to create plankton that can stay in the middle of the water without rising to the surface or sinking to the bottom for longest period of time.
- Divide the students into groups of 3-4 and allow them to take turns grabbing a few materials for their original planktonic creature prototype.
- Students can test their plankton creations and add new materials, take materials away, or reconstruct their planktonic creature as often as necessary during the time allotted for building (approximately 10-15 minutes).
- Have students “race” their plankton in the bucket of water either in pairs, brackets, or groups. The goal is to create planktonic creature that stays in the middle section of the water column for the longest amount of time without touching the bottom or bobbing to the surface.

Discussion

- Have students discuss their design process and share what worked and didn't work when creating their planktonic creatures.
- Tie back to why plankton is so important to the rest of an ecosystem.

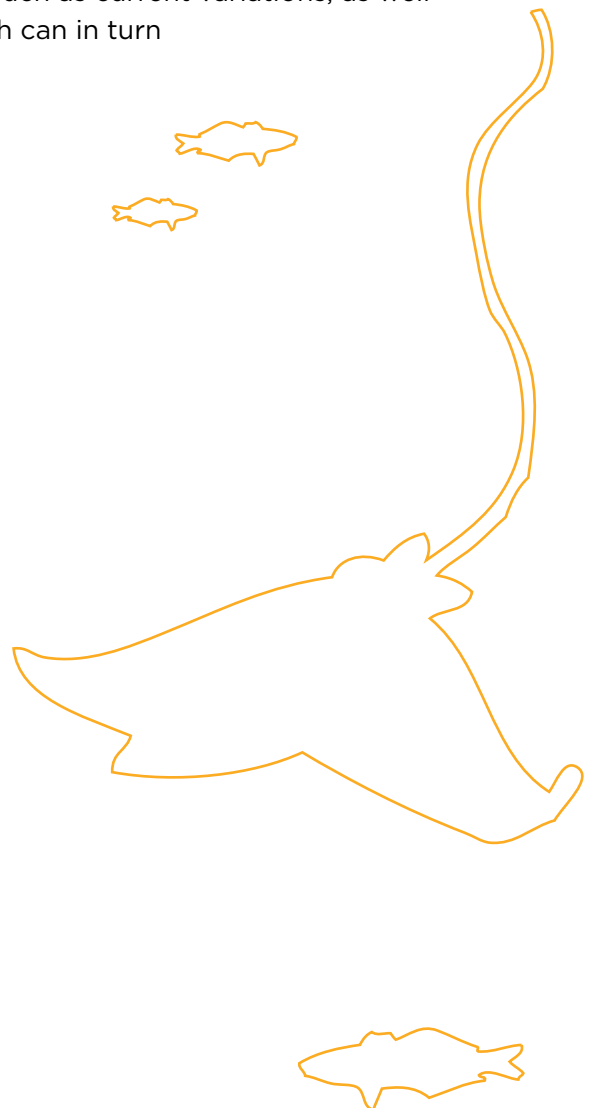


TEACHER BACKGROUND:

Plankton refers to many different organisms found free-floating in bodies of water. The word plankton comes from the Greek word, 'planktos', which means 'drifter'. Thus, plankton typically flows with the ocean currents. There are two subdivisions of plankton, phytoplankton and zooplankton.

Phytoplankton are plant-like organisms that photosynthesize to create energy. Unlike true plants, phytoplankton do not have roots, but instead absorb nutrients from nearly all parts of their bodies. They are agents for "primary production"—the creation of organic compounds from carbon dioxide dissolved in the water—which is a process that sustains the aquatic food web. Phytoplankton not only provide nutrients for larger organisms, they also create at least 50% of the oxygen on planet Earth.

Zooplankton are animal plankton that are also drifters and cannot independently swim against ocean currents. Zooplankton can be holoplanktonic—organisms that are plankton for their whole life cycle—or meroplanktonic—organisms that spend part of their lives as plankton before entering a different stage of their life cycle. While zooplankton primarily consume phytoplankton, many other animals prey upon zooplankton, including clams and mussels, jellies, baleen whales, many species of fish, and almost all fish larvae. Fish rely on the density and distribution of zooplankton to match that of new larvae, which can otherwise starve. Natural factors, such as current variations, as well as man-made factors can strongly affect zooplankton, which can in turn strongly affect global ecosystems.



GLOSSARY:

Plankton: Organisms that live in the water column and cannot swim against a current (derived from the Greek word for 'drifters'). The singular form of plankton is plankter.

Phytoplankton: Plant-like plankton that use photosynthesis to make energy.

Zooplankton: Animal-like plankton that consume phytoplankton and other zooplankton to obtain energy.

Holoplankton: Organisms that are planktonic for their entire life cycle (i.e. diatoms, dinoflagellates, copepods, etc.).

Meroplankton: Organisms that have a planktonic stage in their life cycle (i.e. crabs, sea stars, snails, octopuses, etc.).

STANDARDS:

California Science Standards: Sixth Grade

- 4.a. Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle.
- 5.a. Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.
- 5.b. Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.

California Next Generation Science Standards: Fifth Grade

- 5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
 - The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.
 - A system can be described in terms of its components and their interactions.
- 5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
 - The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water).
 - Energy can be transferred in various ways and between objects.

Middle School

- MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]
 - Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
 - The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.
- MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the

STANDARDS CONTINUED:

numbers of organisms in ecosystems during periods of abundant and scarce resources.]

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]
 - Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.
- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
 - There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
 - Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.

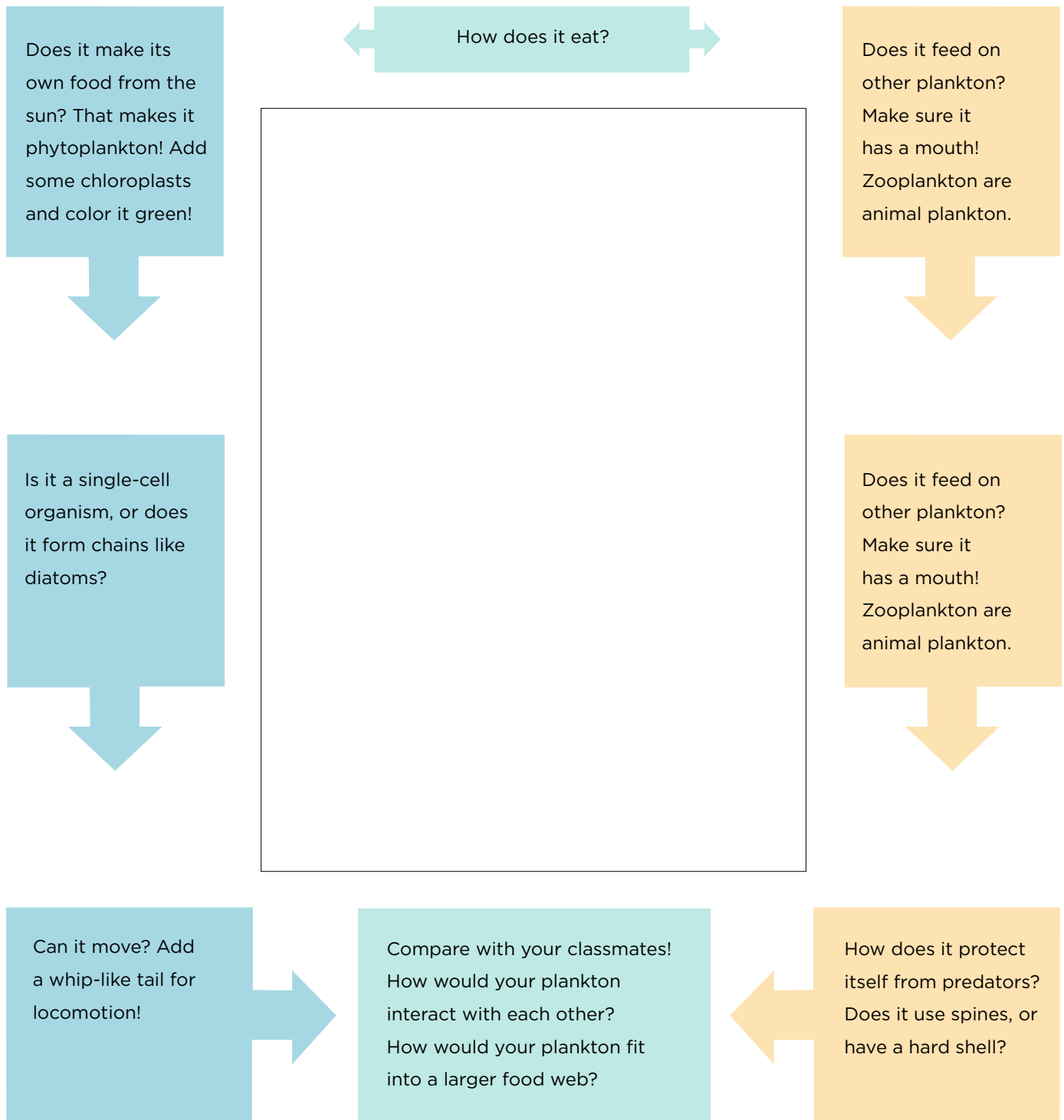
Name: _____

Date: _____

DESIGN YOUR OWN PLANKTON



Draw a plankton-like creature in the rectangle below, then...



ACTIVITY 3

WATER, WATER EVERYWHERE

Enduring Understanding: The salinity of water impacts its density.



Materials

- Enough of these materials to have a set for each small group:
 - Golf ball (or a raw egg)
 - About 6 tbsp. table salt (non-iodized salt works better since the water gets less cloudy)
 - Two clear cups or beakers (at least 16 oz)
 - Labeling materials for the cups or beakers
- Either masking tape and pens or permanent markers
 - Spoon
- Food coloring with significant contrast like red or green (only one color is needed)
- Measuring spoons
- Water source
- Towels for cleaning up any spills, optional

SETUP:

1. Gather the materials.

PROGRAM OUTLINE:

Density & Salinity Experiment Part I

- Divide the students into small groups and have each group collect a set of materials.
- Each group should label one cup/beaker 'salty' and one 'fresh' and fill both halfway full with tap water.
- The students can then dissolve about 6 tbsps. of salt into the water in the cup labeled 'salty' using the spoon to stir thoroughly.
- Then, they should add several drops of food coloring to the fresh water (enough to make the freshwater a noticeably different color to help with differentiation).
- Have the students gently drop the golf ball into one of the two cups and take note of whether the ball sinks, floats, or hangs out in the middle and which type of water was in the cup. The same should then be done with the second cup.

Discussion

- Have the students stop and discuss what happened and try to explain why it happened.
 - Did the golf ball sink or float in the freshwater? (It should sink.)
 - How about in the salty water? (It should float.)
 - Why would it sink in one type of water and float in the other?
 - Explain what density is, if needed (see instructor background and glossary for more details).
 - What might this tell you about the density of these two types

PROGRAM OUTLINE CONTINUED:

of water? (Salt water is more dense than freshwater.)

Density & Salinity Experiment Part II

- Next, challenge the students to get the golf ball to rest in the middle of the water column. Allow students to figure out the problem on their own with minimal teacher support.
- Ideally, the students will suspend the golf ball between a layer of fresh and a layer of salt water. If students have difficulty figuring it out on their own, you can provide any of the tips below to guide them through the following procedure.
 - Remove the golf ball from the cup.
 - Using a spoon to cushion the fall (this is key!), the students can slowly pour the colored freshwater into the cup containing the salty water by directing the stream onto the spoon held just on top of the salty water's surface.
 - Since freshwater is less dense, the colored water should float on top of the clear salty water—this is also why it's best to add the freshwater on top of the salty water layer, otherwise the color would mix in as the two layers switch places.
 - Now, the students can gently place the golf ball into the cup with the water combination and observe where it rests.
- It should float near the boundary between the two water layers—above the salty and below the freshwater—for several days if left undisturbed.

Conclusion

- Once the students have tried to accomplish the golf ball challenge, you can either do a demonstration for the class or ask a group that succeeded to demonstrate their method.
- Why does this matter?
 - Abiotic factors, such as the physical properties of the water, play an important role in the habitat of San Francisco Bay as a dynamic estuary.
 - Animals that use the Bay during all or part of their lifecycle (i.e. salmon) depend on the variability in these factors.



TEACHER BACKGROUND:

Temperature, salinity, and density are physical characteristics of water that are not only all related to each other, but also affect oceanic wildlife. Density is a property of a substance that quantifies the relationship between the mass of the substance and its volume, or how much space it takes up. In other words, density is how much ‘stuff’ is squeezed into the same amount of space.

Temperature and density are inversely related. Heating a substance causes its molecules to speed up and spread slightly further apart, thus occupying a larger volume that results in a decrease in density. Salinity—the dissolved salt content of water—and density share a positive relationship. As the amount of salt in the water increases, the density also increases. Therefore, various events can contribute to changes in the temperature and salinity of seawater, in turn impacting the seawater’s density. All of these physical characteristics of water affect what wildlife can survive in a particular body of water.

The average salinity of the ocean is approximately 35 parts per thousand (ppt). For every 35 parts of salt, there are a thousand parts of water. However, the San Francisco Bay is slightly less saline. The Bay has a lower salinity because it is a place where rivers meet the sea. This mixture of fresh and salt water results in an estuary, a partially enclosed coastal body of brackish water. This type of ecosystem is called an estuary. As one travels closer to the Sacramento and San Joaquin Rivers, the salinity will continue to decrease. Significant changes can also be seen in the water’s salinity, temperature and density as the seasons or weather patterns change.

Overall, changes in these physical attributes of water—temperature, salinity, and density—affect the wildlife of the Bay because different organisms, plant and animal, prefer living in environments with specific temperature and salinity ranges. For example, great white sharks rarely enter the San Francisco Bay because their bodies cannot tolerate the lower salinity of the water.

GLOSSARY:

Density: A characteristic property of a substance that quantifies the relationship between the mass of the substance and how much space it takes up (volume); how much 'stuff' is squeezed into the same amount of space. (Density = Mass/Volume)

Salinity: The salt content of a body of water; how salty water is.

Estuary: An estuary is a partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea.

Brackish: Slightly salty; a mixture of fresh and salt water.



STANDARDS:

California Science Standards:

Sixth Grade

- 5.e. Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

Seventh Grade

- 7.a. Develop a hypothesis.

Eighth Grade

- 8.a. Students know density is mass per unit volume.

California Next Generation Science Standards:

- MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]
 - Develop and use a model to describe phenomena.
- MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]
 - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. [Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]
 - Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.

ACTIVITY 4

OUR WATERS AND US

Enduring Understanding: People's actions anywhere in their watershed have an impact on the environment and wildlife downstream.

Materials

- Blank sheets of computer paper (we recommend scratch paper with a blank side)
- Washable colored markers
- Crayons
- A few spray bottles of water

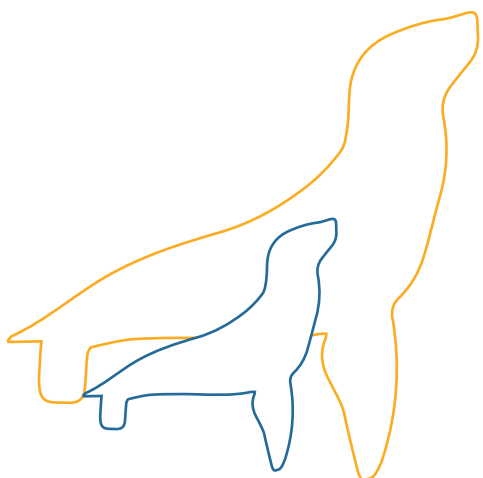
SETUP:

1. Make sure the spray bottles are filled with water and are set to spray more broadly, rather than in one small, direct stream.

PROGRAM OUTLINE:

Personal Watersheds

- Humans' day-to-day actions, including everything from littering to driving cars, agriculture to industrial factories, negatively impact the watershed. Pollution that accumulates on land is washed downstream when it rains. This runoff carries pollutants through the watershed, and can wind up in the Bay.
- Give each student a sheet of paper and have them crumple it into a ball.
- Have the students partially uncrumple the paper so that it looks kind of like a landscape's uneven surface, with mountains and valleys.
- Next, the students should draw some of the natural features of the landscape onto their watershed in crayon. For example, color the peaks and ridges of the mountains green and the valleys and crevices blue to represent where the rivers would flow. They can also add a few trees or animals if they'd like. Make sure the students use crayons for this part so that these drawings do not wash away when the water is added to the watershed.
- Then, the students should use washable markers to draw in some of the human impacts (direct and indirect) on the watershed. Here are a few examples:
 - Oil on roads from driving cars
 - Pesticides and fertilizers on fields for agriculture
 - Oil and other chemicals released at factories
 - Waste from humans, pets, and livestock



PROGRAM OUTLINE CONTINUED:

- Litter and landfill trash
- Anything else they can think of!
- Finally, the students can use the spray bottles to ‘rain’ on their personal watersheds and watch to see what happens. The ‘rain’ water should cause the human impacts (drawn with washable marker) to run off flowing downstream throughout their watershed models. This shows that pollution in one area can actually affect other habitats as it spreads throughout the watershed—this pollution also accumulates in certain areas causing more devastating impacts.

Personal Watershed Debrief

- What happens to the water in their personal watersheds after it rains? What happens to the pollution?
- What effect might that have on the environment and wildlife downstream?
- How could we help reduce these impacts individually in our daily routine? How about as a community?

Group Review

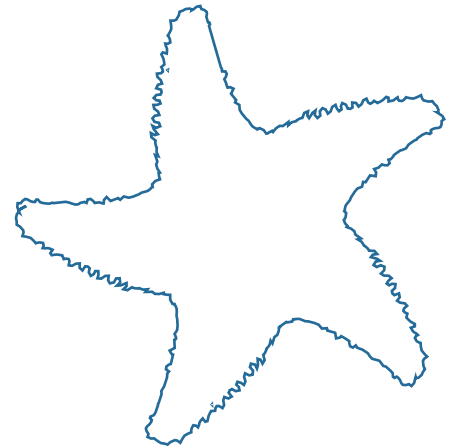
- What is a watershed?
 - The area of land in which all the water that falls in that environment drains to the same location. In other words, a watershed is sort of like a bath tub—any water that falls anywhere in the tub will flow towards the bathtub drain.
- How could humans negatively impact the watershed they live in?
- Can you think of both direct impacts and indirect impacts? (For example, a direct impact would be littering or leaving fishing line or bait behind while on a fishing trip. An indirect impact would be leaving the water on during dish washing using more water, so that less water is left in streams, rivers, and other natural water sources.)



TEACHER BACKGROUND:

A watershed, or drainage basin, is the area of land that drains all of its runoff, snowmelt, rivers, creeks, and groundwater into one body of water. A good analogy for a watershed is a bathtub. The walls of the tub represent the watershed's boundaries and any water that falls within those walls will flow toward the tub's drain. Watersheds come in all shapes and sizes. Their boundaries are defined by hills, mountains, or other higher ground. The San Francisco Bay watershed encompasses half of the state of California. Therefore, all of the water and snow that falls on half of the state eventually drains into the Bay.

People have a huge impact on the watershed they live in. Being a part of the larger system, the daily actions of humans have a profound impact on the organisms that also share the watershed. If a family uses harmful pesticides in their homes and gardens, when it rains, the toxins flow with the water into the rivers and into the bay. Another way that we negatively impact the watershed is by taking too much water out of the environment for our own purposes—household water, agriculture, and / or industry. By polluting less and by conserving fresh water, humans can help protect this vital resource.



GLOSSARY:

Watershed: The area of land that eventually drains its surface water—through rivers, streams, and runoff—and groundwater into a given body of water, such as a lake, bay, or ocean.

STANDARDS:

California Science Standards:

Fifth Grade

- 3.d. Students know that the amount of fresh water located in rivers, lakes, underground sources, and glaciers is limited and that its availability can be extended by recycling and decreasing the use of water.
- 3.e. Students know the origin of the water used by their local communities.

Sixth Grade

- 2.a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.
- 2.b. Students know rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.

California Next Generation Science Standards:

Fifth Grade

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the earth's resources and environment.
 - Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

Middle School

- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]
 - Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

ACTIVITY 5

OBSERVATION

Enduring Understanding: Observation of the natural world is an important part of scientific practice.

Materials

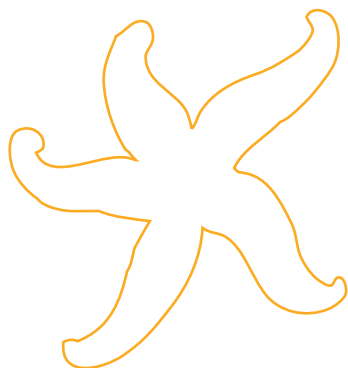
- A flower per student (Carnations are an inexpensive option, but any type of flower would work)
- Paper
- Pencils

SETUP:

1. Gather the materials.

PROGRAM OUTLINE:

- Show the students one of the flowers you will soon be handing out to each of them. Ask them to write down three questions that they might be able to answer/explore through further observation of the flower.
- Pass out one flower to each student, and ask them to come up with at least 15 observations about their flower using as much detail and multiple senses as possible. (Safety note: Avoid using poisonous flowers. If you do use poisonous flowers, make sure to explicitly tell students not to taste.)
- It is ok, and actually encouraged, to take the flower apart piece by piece, analyzing it as closely as possible.
- Give students as much time as they need to observe the flower. Do not stop them if they continue to be on task and engaged.
- Come together as a class and have the students share some of their findings. You can make a master list on the whiteboard or chalkboard to keep track.
 - What are some new questions that their observations have inspired?
 - If they were scientists wanting to answer these questions, what could they do next?
- Discuss how observation is an important tool scientists use to help answer existing questions and to inspire new questions about the natural world.



TEACHER BACKGROUND:

Scientific observation is a central element of the scientific process. It is not only a method that scientists use to answer questions, but it is also often how scientists come up with new questions and hypotheses to base their studies and experiments on. Good scientific observation involves gathering knowledge of the outside world through multiple senses—sight, sound, smell, taste, and touch. Sometimes tools or instruments are used to make and record observations.

Scientists may also make inferences based on their observations. Inferences are explanations for observations. For example, you could observe that your friend is smiling or laughing. Then, you might infer that she or he is feeling happy based on your observations. You could also observe that a cup of coffee is steaming and make the inference that the coffee is hot. However, if you actually touched the cup and it felt warm, you would be using your senses to observe that the coffee is hot.

GLOSSARY:

Observation: Receiving knowledge of the outside world through our senses, or recording information using scientific tools and instruments. Any data recorded during an experiment can be called an observation.

Inference: A conclusion reached on the basis of evidence and reasoning.

STANDARDS:

California Science Standards:

Fifth

- Develop a testable question.

California Next Generation Science Standards:

Middle School

- MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]
- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.