Georgia Aquarium

Teacher's Guide

Grades 9-12

Content created by TurnKey Education, Inc. for Georgia Aquarium
TurnKey Education, Inc.: www.turnkeyeducation.net

Welcome to Georgia Aquarium!
What to Expect on Your Field Trip

Georgia Aquarium is a must-see field trip destination for students (and teachers!) of all ages. On your class trip, you will experience one of the largest indoor ,aquatic habitats and one of the most abundant collections of marine life in the world.

Georgia Aquarium is dedicated to global leadership in the research and conservation of aquatic animals. Since its founding, Georgia Aquarium has been committed to educating and inspiring current and future generations through the respectful display of marine mammals, fish, invertebrates and many other aquatic species. Aquarium staff, volunteers and partners positively impact the future of our planet by instilling in your students an appreciation for these extraordinary animals and empowering them to become advocates on their behalf.

The seven distinct galleries and more than 100 exhibits within Georgia Aquarium represent aquatic environments ranging from arctic to tropical waters. Your students will discover a diverse assortment of animals sure to amaze, inspire and engage them like never before.

Ocean Voyager Built by The Home Depot is the largest exhibit at Georgia Aquarium and represents "our one world ocean." The habitat holds 6.3 million gallons of water and features the whale shark, which is the largest fish in the world, and the only manta rays in a U.S. aquarium. This is also where you can spot Tank, the 450-pound sea turtle!

In **Cold Water Quest,** you will see animals from arctic regions and temperate seas, including beluga whales, southern sea otters and African penguins. If you are lucky, you may see a penguin waddling by during your visit. Trainers lead several African penguins on a daily **Waddle Walk** across the main Atrium. Students can learn firsthand about the plight of this endangered species and the Aquarium's preservation efforts.

Tropical Diver is the colorful home to more than 300 species of fish and other aquatic animals representing Pacific reef ecosystems. With 164,000 gallons of water, the Pacific Barrier Reef habitat is one of the largest living reef exhibits in the United States. Look closely. Approximately 25% of the reef wall is live coral.

Southern Company River Scout is an immersive experience showcasing the diversity of freshwater species around the world. In this gallery, students walk amidst the waters of an overhead river to discover the incredible variety of animals found in the lakes and rivers of Africa, South America, Asia and right here in Georgia. Watch out for the piranha!

SunTrust Pier 225 is home to the charismatic California sea lion. These playful pinnipeds (the name for marine mammals that have front and rear flippers) and their dedicated trainers give students the chance to see training activities firsthand while they learn about sea lion conservation and what they can do to help.

Upstairs in **Aquanaut Adventure: A Discovery Zone,** your students will navigate through a series of activities and challenges. Along the way, they will learn about aquatic animals and ecosystems to become a certified "Georgia Aquarium Aquanaut!"

AT&T Dolphin Tales features an educational presentation that shows your class how the incredible dolphins at Georgia Aquarium are trained and cared for and how to protect dolphins in their natural habitat. In addition, the newly renovated **4D Funbelievable Theater** employs interactive seats and special effects built into the theater itself. There is a rotating series of 20-minute films based on animated theatrical releases. Your field trip tickets include the theater and all animal galleries and presentations. Please know that presentations are subject to availability and are on a first come, first served basis.

Georgia Aquarium offers your students a unique opportunity to see STEAM (science, technology, engineering, the arts and math) learning at work, both above the ground and under the water. You will find that you can use the topic of aquatic life, along with the enriching experiences at the Aquarium itself, to connect the educational themes of the galleries to your national and local STEAM curricula and content requirements.

Using this Teacher's Guide

As a companion to your experience at Georgia Aquarium, this Teacher's Guide has been created to complement your classroom instruction and make the most of your school field trip. It contains original, assessable, STEAM-related classroom lesson plans for you to use and share.

The High School Teacher's Guide includes dynamic activities and assignments for students in grades nine through twelve. There are also Teacher's Guides for Elementary School and Middle School. Each Guide is designed to be flexible and used to best meet the needs and capabilities of your class. You know your students better than anyone else!

Following this **Introduction**, you will find **"STEAM Stream,"** a section consisting of five interdisciplinary Classroom Lesson Plans, each featuring a gallery you will visit on your field trip to the Aquarium. The lesson plans begin with instruction pages and answer keys for teachers that include a list of the appropriate content areas and skills addressed by the activities in the lesson. Rounding out the lessons are ready-to-copy Student Activity worksheets that center on key STEAM topics featured on your tour.

The first lesson plan is "**Cold Water Quest: Classify and Collaborate**." Students will study four species to learn how they are classified and named: penguin, whale, otter and octopus. Then, they will design and build a new enrichment activity for one of these four marine animals based on the requirements and guidelines provided.

"**River Scout: Electrifying Eels,**" the second lesson plan, presents primary sources to show how humans have tried to understand, interpret and describe the electric eel. The selections are accompanied by activities that explore the history, arts and science of this amazing freshwater resident of Georgia Aquarium.

In the next lesson, "**Pier 225: Now Serving Fish Smoothies!**" students will learn more about the nutritional needs of sea lions and why understanding what they eat in their natural habitat helps rescuers save as many as they can during a UME (unusual mortality event).

"Tropical Diver: Chemistry of Coral" includes an experiment highlighting the effects of ocean acidification on coral reefs followed by a very creative, and pH-neutral, option to compensate for centuries of reef-damaging human activity.

The fifth lesson plan is **"Ocean Voyager: Take Out the Trash!"** Students will analyze data on the single most frequent type of marine debris—plastic—and "think globally, act locally" by designing a marine debris awareness campaign specific to their school and community.

Next, in **"Make a Splash,"** games and puzzles relate to themes you encounter on your visit to Georgia Aquarium. Included are a crossword, a word search and Aquarium Jeopardy. These are excellent activities for your bus ride to and from the tour or to assign for extra credit as you see fit. Under **"Beneath the Waves,"** the next section in this Teacher's Guide, you will find facts and figures, a list of Aquarium awareness days and a timeline of Aquarium history.

We know how important it is to justify field trips and document how instructional time is spent outside of your classroom. To that end, this Teacher's Guide is directly correlated to the Common Core State Standards for Mathematics and English Language Arts, the Next Generation Science Standards, the C3 Framework for Social Studies State Standards and the National Core Arts Standards. These correlations are organized by content and grade level. You can readily see how they fit into your required curriculum, making it easy to connect a field trip to Georgia Aquarium with your classroom instruction. Following the national curricula, you will find the Georgia Performance Standards and Standards of Excellence. In addition, specific requirements are provided for Alabama, Florida, North Carolina, South Carolina and Tennessee.

This Teacher's Guide features a curriculum designed to offer a memorable learning classroom experience that is interdisciplinary and applicable across several grade levels. You can use this Guide before and after your visit to Georgia Aquarium, year after year. It will help prepare students for the teachable moments found throughout Georgia Aquarium. When you get back to school, refer to the Guide as you continue to explore connections between the themes of the field trip and your classroom STEAM instruction.

Ready to get started? Let's blow the trainer's whistle and dive right in!

Science, Engineering
Life Sciences, Earth Sciences, Design Process

Lesson Plan 1
Cold Water Quest: Classify and Collaborate

Teacher Instructions

Biologists develop systems and categories to classify and organize all living things on the planet. In the 18th century, a Swedish botanist named Carl von Linné divided everything into two kingdoms: plants and animals. He based these classifications on whether or not the organisms could move around or make their own food (photosynthesis). Since then, thanks to advances in technology, we have discovered many more living creatures. Today, there are six recognized kingdoms of life.

Cold Water Quest at Georgia Aquarium is home to many members of the animal kingdom. Species in this gallery showcase amazing adaptations to harsh environments. From the coasts of South Africa and Japan, all the way north to the Arctic Ocean, **Cold Water Quest** provides a glimpse at life in some of the world's cooler ecosystems. Four of the animals in **Cold Water Quest** are featured in this activity: African penguin, beluga whale, giant Pacific octopus and southern sea otter.

Your students will compare and contrast these four species in Part 1, which has a chart showing their classifications. Students may recognize some of the Latin and Greek root terms found in this classification system. (A bonus lesson in word origins!) Using the information provided, students will answer questions about how these four animals are classified and named. Part 1 is designed for students to complete individually or with a partner.

Because all four of these species—penguin, whale, otter, and octopus—are highly intelligent, they require enrichment activities when they are in human care. In Part 2, your class will divide into teams to undertake a design challenge based on several factors that make these four animals more alike than different. Your students will be charged with designing and building a new enrichment activity—or "toy"—for one of the four marine animals based on the requirements and guidelines provided.

But wait - there is a twist to this challenge! Students must make their enrichment items out of materials that are repurposed, recycled or reused. One thing these animals have in common is the threat to their natural environment from manmade trash. Students are responsible for supplying their own materials based on the team's design plan. At the conclusion, they will present their prototype to the class. Students will need a sink or container of water to prove their inventions are waterproof, along with internet access to conduct their background research.

Part 2 can be done in less than a week or it can be as involved as you would like it to be! Start by dividing your class into groups and either assigning a species to each group or letting each team select one. If time permits, begin by instructing each student to submit their own design idea to be voted on by their team. At the other end of the project's timeline, students can build a new and improved model based on what they learned during their design process.

Answer Key

Part 1

1. (a.) giant Pacific octopus; (b.) Mollusca
2. Chordata
3. The class “Aves”
4. (a.) 8, “octo” means eight; (b.) octagon; (c.) a person in their 80s
5. Sea otter
6. Whale and otter; both in the mammal class
7. It’s the first part of the name.
8. Answers will vary, but should address the shape of the wing and/or the shape of the body in general.
9. The beluga is a white marine animal similar to a dolphin without the dorsal fin (“wing”) normally associated with whales.
10. Giant Pacific octopus

Part 2

Criteria	**0 points**	**1 point**	**2 points**
Collaboration	Team did not work together well	Team worked together, but struggled	All team members were collaborative
Research	No ideas or website listed	1 or 2 websites and ideas listed	3 websites and ideas listed
Brainstorm	0 or 1 item addressed	2 to 4 items addressed	All 5 items addressed
Plan	No materials or sketch	Missing list of materials or design sketch	Completed list of materials and provided a sketch of the design
Build & Demonstrate	No complication described, and prototype not tested in water	Either complication described or tested in water, but not both	Complication described and prototype tested in water
Evaluate	None of the questions answered	1 question answered	Both questions answered

Total: ________ /12 points

Name Class Date

Cold Water Quest: Classify and Collaborate

Student Activity

Biologists develop systems and categories to classify and organize all living things on the planet. In the 18th century, a Swedish botanist named Carl von Linné divided everything into two kingdoms: plants and animals. He based these classifications on whether or not the organisms could move around or make their own food (photosynthesis). Since then, thanks to advances in technology, we have discovered many more living creatures. Today, there are six recognized kingdoms of life.

Cold Water Quest at Georgia Aquarium is home to many members of the animal kingdom. Species in this gallery showcase amazing adaptations to harsh environments. From the coasts of South Africa and Japan, all the way north to the Arctic Ocean, **Cold Water Quest** provides a glimpse at life in some of the world's cooler ecosystems. Four of the animals in **Cold Water Quest** are featured in this activity: African penguin, beluga whale, giant Pacific octopus and southern sea otter.

After you compare and contrast these four marine animals in Part 1, you will undertake a design challenge based on several factors that make these animals more alike than different. Because the penguin, whale, octopus and otter are highly intelligent, they require enrichment activities when they are in human care. You will be charged with designing and building a new enrichment activity—or "toy"—for one of these four animals based on the requirements and guidelines provided in Part 2. Your **Cold Water Quest** design challenge has a twist! Since the natural environments of these animals are threatened by manmade trash, your enrichment item must be made out materials that are repurposed, recycled or reused.

Terms to Know: *ballast, breeding, cephalopod, cetacean, dorsal, enrichment, invertebrate, non-biodegradable, phyla, propel, prototype, repertoire, taxonomist, vertebrate*

GEORGIA AQUARIUM

Name ______________________ Class __________ Date __________

African Penguin

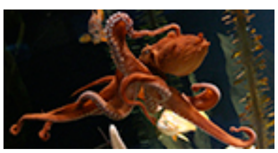
While penguins might look clumsy and awkward on land, they are perfectly engineered for an aquatic life. Unlike the hollow bones in birds that can fly, the penguins' bones are solid to provide ballast when diving. The shape of their wings helps propel them through the water up to 12.5 mph for short bursts. Even their vision, which is nearsighted on land, is excellent underwater.

The African penguin is an endangered species. It is threatened by natural predators, loss of natural habitats and food supplies, and oil spills. As its name suggests, this penguin is found in Africa. Specifically, it lives on the coast and on 24 islands at the southern tip of South Africa and Namibia. African penguin populations have dropped 60% in the last 30 years. Georgia Aquarium helps these animals through breeding programs and partners with a conservation organization in South Africa.

Beluga Whale

When you hear a beluga whale for the first time, you will understand why this animal is nicknamed the "sea canary." Belugas have the most diverse vocal repertoire of all cetaceans. Their sounds include whistles, clicks, chirps, groans, trills, buzzes, roars and pulses. This "language" is one of the many characteristics that demonstrate the high intelligence and social nature of these animals.

Belugas have unique physical adaptations that allow them to survive and thrive in the Arctic Circle. Pale grey to white skin (10 times thicker than the skin of a dolphin!) camouflages perfectly with ice and snow. To conserve body heat, belugas have a dorsal ridge instead of a dorsal fin. Their flippers and flukes are also smaller than those of other whales because less surface area means less body heat can escape.



Giant Pacific Octopus

The most intelligent invertebrate on Earth lives in the Pacific Ocean, from tidal shallow pools to caves almost a mile beneath the surface and everywhere in between. The giant Pacific octopus is the largest species of octopus in the world. No bigger than a grain of rice at birth, it can grow to 16 feet from the top of its head to the tips of its eight arms. Each arm has two rows of suckers, with as many as 250 suckers on each one.

As a member of the Mollusca phylum, the octopus is related to snails and clams. Its class, cephalopod, means "head-foot" because its eight "feet" are attached to its "head," which holds a beak, a large brain and three hearts that pump blue blood. Usually reddish-brown in color, the octopus is a master at camouflage, just like other cephalopods. It can change both the texture and the color of its skin in an instant.

Southern Sea Otter

Sea otters are found in coastal areas along the northern Pacific Ocean. The southern sea otter is a subspecies that lives along the coast of central California. They rarely venture onto land, preferring environments with rocky or muddy sea bottoms. Sea otters can even sleep in the sea by wrapping up in strands of kelp to keep from floating away!

Sea otters are marine mammals, but as members of the family Mustelidae, they are closely related to weasels and wolverines. Because sea otters do not have blubber, they have the densest fur of any animal on earth to stay warm. They also eat 20% to 25% of their body weight each day to maintain their temperature. The feeding behaviors of sea otters showcase their intelligence and curiosity. They even use rocks as tools to get to their preferred snacks!

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Name ____________________ Class __________ Date __________

Part 1

The animal kingdom is separated into two groups or subkingdoms: vertebrates, those that have backbones, and invertebrates, those that don't. Vertebrates are further divided into birds, reptiles, mammals, amphibians and fish. The diverse collection of life at Georgia Aquarium includes representatives from several invertebrate phyla and all five vertebrate phyla.

The chart below shows the classifications for four species in **Cold Water Quest**. You may recognize some Latin and Greek root terms in this classification system. (A bonus lesson in word origins!)

Read the descriptions of the animals on the previous page and the information in the chart below to answer ten questions about how these four animals are classified and named.

	African Penguin	**Beluga Whale**	**Southern Sea Otter**	**Giant Pacific Octopus**
Kingdom	Animalia	Animalia	Animalia	Animalia
Group or Subkingdom	Vertebrate			Invertebrate
Phylum	Chordata	Chordata	Chordata	Mollusca
Class	Aves	Mammalia	Mammalia	Cephalopoda
Order	Sphenisciformes	Cetartiodactyla	Carnivora	Octopoda
Family	Spheniscidae	Monodontidae	Mustelidae	Octopodidae
Genus	*Spheniscus*	*Delphinapterus*	*Enhydra*	*Enteroctopus*
Species	*Spheniscus demersus*	*Delphinapterus leucas*	*Enhydra lutris nereis*	*Enteroctopus dofleini*

1. (a.) Which of these four animals does not have a backbone? (b.) What is its phylum?

____

____

2. What is the name of the phylum for the three vertebrates?

____

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Name ____________________ Class __________ Date __________

3. One synonym for bird is “avian.” Look at the classification for the penguin. What do you think is the origin of the word “avian”?

4. (a.) How many feet, or “pods,” does an animal in the order Octopoda have?
(b.) Name a geometric term that also uses the “octo” prefix.
(c.) What do you think “octogenarian” means?

5. All four of these animals are carnivores, but only one is in the order Carnivore. Which one?

6. Which two of the four animals are most closely related? How do you know?

7. How does the species’ genus feature in its scientific name?

8. The word for the African penguin’s genus, *Spheniscus*, comes from Latin, and originally ancient Greek. It means “wedge-shaped.” Why do you think the penguin was given this name?

9. The scientific name for the beluga whale is *Delphinapterus leucas.* It translates from Greek as white (*leucas*) dolphin (*delphis*) without a wing (*apterus*). Why is this an appropriate description for the beluga?

10. One of these animals was named in honor of German zoologist Franz Doflein (1873-1924). Which animal is it?

Name Class Date

Part 2

These four species may look very different, but their intelligence and their environments make them more alike than it appears. What do they have in common?

They…

- live in salt water that is less than 60^{O}F.
- have diets that include fish and invertebrates like clams, crabs, mussels, squid and shrimp.
- are highly intelligent animals.
- are threatened by ocean pollution in their natural environments.
- receive enrichment items specially selected for their species when they are in human care.

These commonalties also form the basis of your design challenge! Your class will be divided into groups. Each group will choose or be assigned one of these four animals: African penguin, beluga whale, giant Pacific octopus or southern sea otter.

The first step in the Engineering Design Process is to define your problem. In this case, you need to create an animal enrichment activity out of repurposed or recycled materials. Use the Guiding Questions and the Design Plan Worksheet on the following pages to research, plan and build your activity or toy. At the conclusion, submit your worksheet to your teacher and present your enrichment item to the class. Maybe you will see your plan in action in one of the **Cold Water Quest** habitats on your next trip to Georgia Aquarium!

GEORGIA AQUARIUM

Name ______________________________ Class ______________ Date ______________

Guiding Questions

1. What is the purpose of your enrichment object?

Enrichment activities and objects at aquariums and zoos are created for three main reasons. Which category will your group choose?

- First, they are used to teach an animal a certain movement that makes it easy to do medical care. For example, animals can be taught to roll over and show their bellies during an exam.
- Another reason for enrichment is to practice behaviors that an animal needs to survive in their natural habitat. These behaviors include hunting for dinner.
- The third reason is because animals should be mentally and physically stimulated so that they're healthy and thriving.

2. Is it appropriate for your animal?

Think about the things your animal does naturally and how it uses its senses. Research the species to learn about what they are good at and what they prefer to do.

- Do they usually have to work for their food, like an otter smashing open a clam? Otters prefer breaking apart "popsicles" with a snack frozen inside.
- Do they use multiple senses at once, like an octopus who tastes and touches with its suckers? A hamster ball with a treat inside can occupy an octopus as it figures out how to open the ball.
- Do they prefer to collect things, like a penguin gathering sticks and branches for its nest? Natural materials like small branches can be reused as nest-building materials for penguins.
- Is sound and communication part of their daily life, as it is for belugas?

3. Is it safe?

Enrichment is supposed to be stimulating, not dangerous!

- If it incorporates food items, are they safe for the animal?
- Can the animal use it without help from people?
- Is it safe for other animals in the same habitat?
- Are there any sharp edges? If it falls apart, will sharp edges be revealed?
- Could the animal throw it out of the habitat?
- Are there holes where body parts could get stuck?
- Are there pieces the animal could choke on?
- Are the materials waterproof and non-toxic?

GEORGIA AQUARIUM

Design Plan: Cold Water Quest Animal Enrichment

Team Members: ______________________________
____
____

Animal Species: ______________________________

Name of Product: ______________________________

Research: Take a look at other enrichment ideas for your species that are currently being used in zoos and aquariums, including Georgia Aquarium. Select three that your team found inspiring. Record the website and describe the idea.

Website	**Idea**
1.	
2.	
3.	

Brainstorm: Describe one idea for this project that your team rejected and the reason(s) why. Then explain how the idea your group selected addresses the Guiding Questions. Use separate pages if necessary.

1. One idea we rejected, and the reason for rejecting it, is: ______________________________
____
____
____
____
____
____

2. The idea we agreed upon is: ____

3. The enrichment purpose of our idea is: ______________________________________

4. It is appropriate for our animal because: _____________________________________

5. It is safe for our animal because: ____

Plan: Non-biodegradable plastics are found in every ocean of the world. Instead of adding to the trash that threatens whole ecosystems, find a new use for it. List your materials here and include a sketch of your plan on separate paper.

Materials:

Build: As you build your prototype, you will encounter unexpected problems. Describe one such complication and how your group adapted.

Demonstrate

1. Test your enrichment item in water before you present it to your class.
2. During your group's demonstration, describe how it was made and how it is meant to be used by the animal. Ask your classmates for ideas on how to further develop your design.

Evaluate: In the Engineering Design Process, the final step always leads back to the first step. Based on your experience as a team and the feedback you received from your class, think about how you might improve your eco-friendly enrichment activity. (a.) What changes would your team make to a second version of the prototype? (b.) Which step of the design process was most difficult for your team and why?

The penguins go for a "Waddle Walk" around the Aquarium as part of their enrichment program.
http://news.georgiaaquarium.org/multimedia/album?id=573f553d2cfac25bf63cf97a&t=photo&p=16&s=order

This dolphin presents its belly during an Animal Encounter program at the Aquarium. Behaviors like these are important because they allow medical staff to examine an animal and provide care when needed.
http://news.georgiaaquarium.org/multimedia/album?id=53f4adaf7241c80db8006fb6&t=photo&p=16&s=order

Science, Social Studies
Life Sciences, Physics, History, Geography

Lesson Plan 2
River Scout: Electrifying Eels
Teacher Instructions

The **Southern Company River Scout** gallery at Georgia Aquarium showcases a wide variety of animals found in the rivers of four continents - Africa, South America, Asia; and North America. One of the South American animals in **River Scout**, the electric eel (*Electrophorus electricus*), is so special that it is the only member of its genus! Electric eels are carnivorous natives of the Amazon and Orinoco Rivers. They live in murky freshwater, hunt nocturnally, and can grow to nearly eight feet in length.

What makes this species so unique? Despite its name, it is not even an eel! It is a naked-back knifefish, more closely related to catfish or carp than eels, with an elongated body and no dorsal or pelvic fins. Although it is a fish, it breathes air. It has gills but receives 80% of its oxygen through its mouth and must surface regularly for a breath of fresh air. This eel even prepares for its offspring in an unusual way—the father builds a nest for the eggs out of his own saliva!

It is the electric eel's electricity, of course, that makes it truly fascinating. The eel has captured the curiosity of humans since before the word "electricity" even existed. A full grown eel can generate over 500 volts of energy in milliseconds, which is enough to kill smaller creatures and stun larger ones. The fish's ability to produce electricity has contributed to centuries of ground-breaking research in many branches of science.

Europeans first became aware of electric eels after South America was conquered and colonized during the Age of Discovery. The search for El Dorado (a mythical city of gold) in the rainforests brought soldiers and scientists to the Amazon River basin. Beginning with some of the earliest accounts of the electric eel available in English, your students will use primary sources to see how humans have tried to understand, interpret and describe the electric eel. The selections are accompanied by activities that explore the history and science of this amazing freshwater resident of Georgia Aquarium.

Part 1: The Numb Eel

This section has excerpts from two 17th century descriptions of the electric eel. Students will read both passages and answer the questions that follow. The first selection is from Cristóbal de Acuña, a Spanish priest, and the second is from George Warren, an American doctor.

Source for Cristóbal de Acuña: *Voyages and discoveries in South-America the first up the river of Amazons to Quito in Peru, and back again to Brazil, perform'd at the command of the King of Spain by Christopher D'Acugna : the second up the river of Plata, and thence by land to the mines of Potosi by Mons Acarete : the third from Cayenne into Guiana, in search of the lake of Parima, reputed the richest place in the world by M. Grillet and Bechamel : done into English from the* *originals, being the only accounts of those parts hitherto extant : the whole illustrated with notes and maps*. London, 1698. http://name.umdl.umich.edu/A65182.0001.001

Source for George Warren: *An Impartial Description of Surinam upon the Continent of Guiana In America. With a History of Several Strange Beasts, Birds, Fishes, Insects, and Customs of that Colony, etc. Worthy of the Perusal of all, from the Experience of George Warren, Gent.* London, 1667. https://archive.org/stream/animpartialdesc00warrgoog#page/n12/mode/2up

Answer Key

1. Acuña, Spanish; Warren, English
2. He says the Indians call the eel Paraque, which is very similar to poraquê, and his account is from a Portuguese trip of exploration.
3. Coldness and Shivering; an Ague a Coldness and Shivering; an Ague
4. Torpedo, Num-Eele
5. He describes how the shock can be felt through a pole or through another person. (*It produces the like Effect if but touched with the end of a long Pole, or one man immediately laying hold of another so benumbed.)*

Part 2: The Torporific Eel

Edward Bancroft lived in the Dutch colony of Guiana in the 18th century. He was one of first scientists to suggest that the force created by an electric eel is electricity. The excerpt from his book provides a physical description of the fish. Students will use the details from Bancroft to take on the role of an 18th century graphic artist and illustrate his "Torporific Eel."

Students will sketch their eels on a separate piece of paper. There are 13 details in Bancroft's description. Assess your students' work based on their individual skill level and the number of items from this list that are included. Images should be proportionate or drawn to scale (not actual size).

- three feet in length
- twelve inches in circumference near the middle
- covered with a smooth skin of a "blueish lead" color… entirely destitute of scales
- head is equal in size to the largest part of his body, but somewhat flat on the upper and lower sides
- its [head's] upper surface is perforated with several holes
- upper and lower jaws extend an equal distance, terminating in a semicircular shape
- wide mouth without teeth
- on the back part of the head are two small fins, one on each side
- from about eight inches below the head the body gradually diminishes in size to the tail
- tail ends in a point, without a fin
- under the belly is a fleshy fin, about half an inch in thickness, and near three inches wide, extending from the head to the point of the tail, but diminishing in width, as the body diminishes in size
- the fin under the belly with the two fins on the head are all that are found on the body
- [the body] would be nearly round if deprived of the belly-fin

<u>Supplies</u>: blank paper, colored pencils

Source for Edward Bancroft: *An essay on the natural history of Guiana, in South America: Containing a description of many curious productions in the animal and vegetable systems of that country. Together with an account of the religion, manners and customs of several tribes of its Indian inhabitants. Interspersed with a variety of literary and medical observations.* London, 1769. http://catalog.hathitrust.org/Record/001490693

Part 3: The Electric Eel

In the early 19th century, Alessandro Volta was inspired by new research on how an electric charge accumulates and moves through an eel. After students analyze an excerpt in which Volta describes how he made his first battery, they will be challenged to design a "flashlight eel" that works under the same principles. Prepare the battery kits in advance; there should be one for each student or group of students working together. Do not provide instructions on how to make the flashlight until students have worked through the engineering design process.

As long as the batteries are wired in series and not in parallel, there are many ways to construct a working flashlight.Students will not need to use all of the materials provided, depending on their individual designs. The batteries will all be the standard 1.5 volts, but different sizes will allow for more variety in the students' designs. The lights will work best when two batteries of the same size are connected end-to-end, beginning with the negative pole at the end of what will be the flashlight handle. Depending on your students' level, you can simplify the process by providing only D-batteries and omitting the PVC pipe.

<u>Supplies</u>:

- Periodic table of the elements: if the class science textbook does not have a periodic table, many versions can be found online including this one in the public domain from the National Institute of Standards and Technology: www.nist.gov/pml/data/periodic.cfm.
- Battery kit for the flashlight eel:
    - aluminum foil
    - small paper cup
    - notecard
    - empty toilet paper or other cardboard tube
    - 4-inch PVC pipe, ¾-in diameter
    - 2 D batteries
    - 2 C batteries
    - 2 AA batteries
    - 15 cm of wire, such as copper speaker wire
    - 3-volt light bulb
    - wire strippers
    - wire cutters
    - paper clips
    - brass brads
    - scissors

Source for Alessandro Volta: "On the Electricity excited by the mere Contact of Conducting Substances of different kinds. By Mr. Alex Volta, F.R.S. Prof. of Nat. Philos. in the Univ. of Pavia. From the

French. 1800." *The Philosophical Transitions of the Royal Society of London. Vol. XVIII. From 1796 to 1800.* London, 1809. https://books.google.com/books?id=TvVbAAAAcAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

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Answer Key

1. About an inch in diameter
2. (a.) Copper (Cu), tin (Sn), silver (Ag), zinc (Zn); (b.) silver and zinc; (c.) high conductivity and low resistivity
3. Soaked in water or other liquid, because liquids increase conductivity
4. Circles
5. (b.) The flashlight will only work if the batteries are wired in series and not in a parallel circuit. (c.) The total voltage of the flashlight eel will be 3 volts (number of batteries multiplied by 1.5, the individual voltage of each battery).

GEORGIA AQUARIUM

Name Class Date

River Scout: Electrifying Eels

Student Activity

The **Southern Company River Scout** gallery at Georgia Aquarium showcases a wide variety of animals found in the rivers of four continents - Africa, South America, Asia and North America. One of the South American animals in **River Scout**, the electric eel (*Electrophorus electricus*), is so special that it is the only member of its genus! Electric eels are carnivorous natives of the Amazon and Orinoco Rivers. They live in murky freshwater, hunt nocturnally and can grow to nearly eight feet in length.

What makes this species so unique? Despite its name, it is not even an eel! It is a naked-back knifefish, more closely related to catfish or carp than eels, with an elongated body and no dorsal or pelvic fins. Although it is a fish, it breathes air. It has gills but receives 80% of its oxygen through its mouth and must surface regularly for a breath of fresh air. This eel even prepares for its offspring in an unusual way—the father builds a nest for the eggs out of his own saliva!

It is the electric eel's electricity, of course, that makes it truly fascinating. The eel has captured the curiosity of humans since before the word "electricity" even existed. A full grown eel can generate over 500 volts of energy in milliseconds, which is enough to kill smaller creatures and stun larger ones. The fish's ability to produce electricity has contributed to centuries of ground-breaking research in many branches of science.

Europeans first became aware of electric eels after South America was conquered and colonized during the Age of Discovery. The search for El Dorado (a mythical city of gold) in the rainforests brought soldiers and scientists to the Amazon River basin. Beginning with some of the earliest accounts of the electric eel available in English, you will use primary sources to see how humans have tried to understand, interpret and describe the electric eel. The selections are accompanied by activities that explore the history and science of this amazing freshwater resident of Georgia Aquarium.

Terms to Know: *ague, conduction, conger, destitute, dorsal, genus, indigenous, imbibing, malaria, pelvic, perforated, render, semiconductor, simulate, sonar, torporific*

Name Class Date

Part 1: The Numb Eel

Indigenous peoples of South America described an electric eel as “numb,” “sleepy,” or “cold,” referring to the sensation of the eel’s shock. When translated to the European languages of early explorers and settlers, the eel was sometimes called a “tremble fish” or “torpedo.” Excerpts from two early descriptions of the electric eel are provided below. Read both passages and answer the questions that follow.

Cristóbal de Acuña was a Spanish Jesuit priest from Peru who accompanied a Portuguese general exploring the Amazon River in 1639. General Pedro Teixeira became the first European to travel the entire Amazon River. Acuña’s notes and memoirs were translated into English and published in 1698.

There is one [fish] amongst the rest which the Indians call Paraque, which resembles a great Eel, or rather a small Conger, which has a very strange Property; for if a Man takes it in his Hand while 'tis alive, immediately a Coldness and Shivering seizes him, as if he were taken with a fit of an Ague; but the shaking presently ceases upon letting it go out of his Hand again.

George Warren was the author of a short book describing the animals, plants and people of Surinam when it was a British Colony. The narrative was published in London in 1667. Little is known about Warren, other than the fact that he lived in this colony for three years.

Tis the Torpedo or Num-Eele [numb eel], which, being alive, touching any other Living Creature, strikes such a deadliness into all the parts, as for awhile renders them wholly useless, and indefensible, which, is believed, has occasioned the Drowning of several persons who have been unhappily so taken, as they were Swimming in the River. It produces the like Effect if but touched with the end of a long Pole, or one man immediately laying hold of another so benumbed.

1. Both of these descriptions are from the 17th century. What were the nationalities of the two authors?

______

______

2. Today, the Portuguese word for an electric eel is *poraquê*. It comes from the word for “sleepy” in the language of the Tupi people. The Tupi inhabited much of what is now Brazil when the Portuguese first arrived. How does Acuña’s account match the history of this word?

______

______

______

3. How does Acuña describe the sensation from the electric eel? To what illness (which we now know is malaria) does he compare it?

______

Name ______________________________ Class ____________ Date ____________

4. What two names does Warren give for the electric eel?

____

____

5. How does Warren unknowingly provide an example of electrical conduction?

____

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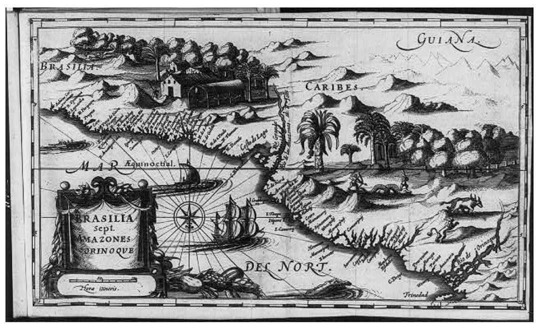

"Map of northern coast of S. America, showing mouths of Amazon and Orinoco rivers. Illus. with dwellings, boats, animals; Indians killing boa" is an engraving from a 1624 Dutch book, Reys-Boeck van het rijcke Brasilien*. (Library of Congress)*
http://www.loc.gov/pictures/item/2003663635/

Part 2: The Torporific Eel

Supplies: blank paper, colored pencils

Edward Bancroft led a busy life as a doctor, scientist, author and even a double agent during the American Revolution. Part of his time was spent as a physician on sugar plantations in Dutch Guiana. His scientific writings from South America were published in 1769. The book included one of the early explanations in English of why the shock from the "Torporific Eel" was actually electricity, a phenomenon popularized by Benjamin Franklin's experiment with the key, kite and lightning in 1752.

Bancroft's account is also valuable for the physical description he gives of the fish. Scientists elsewhere relied on reports from world travelers like Bancroft to further their own work. Without photography, drawings and paintings were the only images of exotic species. Using details from Bancroft, take on the role of an 18th century graphic artist to illustrate the Torporific Eel. Sketch your eel on a separate piece of paper. Images should be proportionate or drawn to scale, not actual size.

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This fish is a native of fresh water, and is most commonly found in the River Essequibo [largest river in Guyana] being usually three feet in length, and twelve inches in circumference near the middle. It is covered with a smooth skin of a blueish lead color…entirely destitute of scales. The head is equal in size to the largest part of his body, but somewhat flat on the upper and lower sides, and its upper surface is perforated with several holes, like those of a Lamprey Eel. The upper and lower jaws extend an equal distance, terminating in a semicircular shape, and forming a wide mouth without teeth. On the back part of the head are two small fins, one on each side….

From about eight inches below the head the body gradually diminishes in size to the tail, which ends in a point, without a fin. Under the belly is a fleshy fin, about half an inch in thickness, and near three inches wide, extending from the head to the point of the tail, but diminishing in width, as the body diminishes in size: this, with the two fins on the head, are all that are found on the body of this Eel, which would be nearly round if deprived of the belly-fin.

Part 3: The Electric Eel

Supplies: periodic table of the elements, battery kit

By the end of the 18th century, the fact that this fish, and others including catfishes and rays, produced electricity was widely accepted. Scientists knew that the vital organs in an electric eel were compressed in an area right behind the head. The tail, which makes up about 80% of the body, contains three organs that produce the electricity: Sach's organ, main organ and Hunter's organ. Eels use their low-voltage pulses from the Sach's organ like sonar. High-voltage discharges come from the main organ and the Hunter's organ. These are the powerful shocks used for self-defense and to immobilize prey.

The electricity in the eel is produced by specialized muscle cells called electrocytes and served to inspire inventor Alessandro Volta, for whom the volt is named as a unit to measure electric potential. The design of Volta's first battery—the "Voltaic pile"—was similar to how the electrocytes are lined up in the fishes' tails. Volta even describes his invention as an "artificial electric organ." Read the passage below and answer the questions that follow. A periodic table of the elements might be helpful in your research and you will need the battery kit provided by your teacher to complete this section.

Name ________________ Class ________ Date ________

For the construction of this instrument, Volta provides some dozens of small, round metal plates of copper, or tin, or best of silver, about an inch in diameter, like shillings or half-crowns, and an equal number of plates of tin, or much better of zinc, of the same shape and size. These pieces he places exactly one upon another, forming a column, pillar or pile. He also provides as many small round pieces of card, or leather, or such like a spongy matter, capable of imbibing and retaining much of the water, or other liquid when soaked in it. These soaked roullets, or circles, are to be a little less in diameter than the small metal discs or plates that they may not jut out beyond them. All these discs are then placed horizontally on a table, one over another continually alternating, in a pile as high as will well support itself without tottering and falling down: beginning with a plate of either of the metals, as for instance, the silver, then upon that one of zinc, over which is to be put the soaked card; then other three discs, over these in the same order, viz. a silver, next a zinc, and then another moistened card, etc.

1. What should be the size of the "dozens of small, round metal plates" used to form a column?

2. (a.) List the three metals Volta recommends for the round plates. What are their symbols? (b.) Which does Volta say are best? (c.) What property or properties make these metals particularly good choices for Volta's artificial electric organ? (Hint: check the periodic table.)

3. Dry leather is a semiconductor. What should be done to the leather, or other "spongy matter," used for the smaller circles between the metal circles?

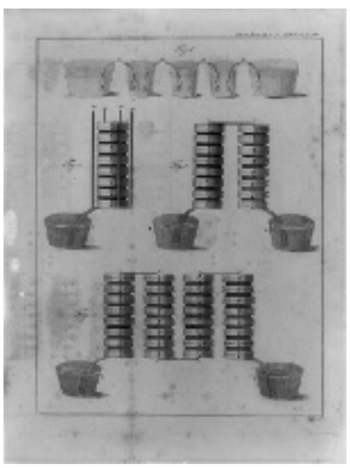
4. Volta originally wrote this article in 18th-century French. What does "roullets" mean?

Name Class Date

5. Each electrocyte in an eel produces a very small charge, about 0.15 volt, but the volts accumulate quickly as the charge passes through thousands of these cells. Volta's battery worked in much the same way, with the charge building as it passed through each set of metal discs. (a.) Use the battery kit provided by your teacher to design a "flashlight eel" with a circuit that simulates these charges. (b.) What kind of circuit did you make? (c.) How many volts does your "eel" emit?

An 18th century illustration of an electric eel, or Gymnotus Electricus *as it was known, by German physician and naturalist, Marcus Bloch. (The New York Public Library)*

http://digitalcollections.nypl.org/items/510d47da-6a61-a3d9-e040-e00a18064a99



The Voltaic pile was inspired by the electrocytes of an electric eel. Volta stacked groups of silver, zinc and a card soaked in salt water to increase the strength of the current. (Library of Congress)

http://www.loc.gov/pictures/item/92518975/

GEORGIA AQUARIUM

Mathematics Science, Social Studies

Statistics, Algebra, Life Sciences, Primary Source

Lesson Plan 3
SunTrust Pier 225: Now Serving Fish Smoothies!

Teacher Instructions

As part of your class field trip, your students will enjoy a presentation called "Under the Boardwalk" in the **SunTrust Pier 225** gallery. There they will meet Georgia Aquarium's charismatic California sea lions (*Zalophus californianus*). Two of the male sea lions, Neptune and Jupiter, are survivors of a recent unusual mortality event, or UME. These two animals, along with thousands more, were found stranded, malnourished and underweight on the shores of California in 2015.

Despite multiple attempts to rehabilitate these two sea lions, they continued to wash ashore and were deemed non-releasable by the National Ocean and Atmospheric Administration (NOAA Fisheries). When an animal can no longer be released back to its natural habitat, homes are found for them in the zoological community. Georgia Aquarium is proud to provide a caring home to these pinnipeds, the name given to marine mammals that have front and rear flippers. Along with the other rescued California sea lions in **Pier 225**, Neptune and Jupiter help educate the public about the challenges these animals face in their natural habitat in the Pacific Ocean, including dwindling food sources. Watch Neptune and Jupiter make their journey from California to Atlanta in this short video: "Caring Together for Sea Lions: Rescue and Arrival," (www.youtube.com/watch?v=29yBPKrJDTA).

The Marine Mammal Center in California is the world's largest marine mammal rescue and rehabilitation facility. In 2015, Georgia Aquarium sent some of its staff to the Center to help care for the overwhelming numbers of sea lions admitted during the UME. One of their tasks included tube feeding weak sea lion pups with a "fish smoothie." In this lesson plan, your students will learn more about the nutritional needs of sea lions and why understanding what they eat in their natural habitat helps rescuers save as many as they can during a UME.

The primary source excerpt used in Part 1 comes from "Notes on the Food Habits of California Sea-Lions" by L. L. Dyche, published in 1903 as part of *Transactions of the Kansas Academy of Science.* The complete article can be found here: www.jstor.org/stable/3624791?origin=crossref&seq=1#page_scan_tab_contents. The source for the forage fish data in Part 2 is the article "Food limitation of sea lion pups and the decline of forage off central and southern California." It appears in the journal *Royal Society Open Science*, published in March 2016: http://rsos.royalsocietypublishing.org/content/3/3/150628#abstract-1.

The ingredients for the sea lion fish formula in Part 3 can be found in two different books: *Hand-Rearing Wild and Domestic Mammals,* by Laurie Gage, and *CRC Handbook of Marine Mammal Medicine*, second edition, edited by Leslie Dierauf and Frances Gulland.

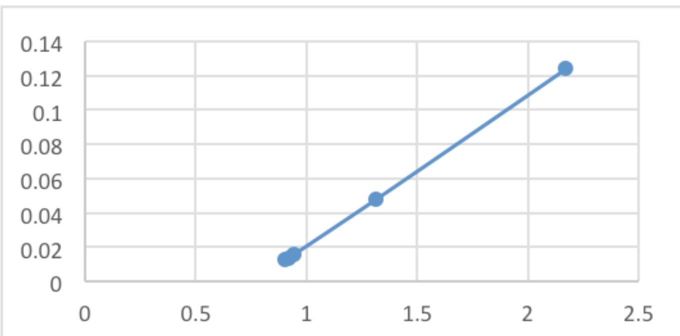
GEORGIA AQUARIUM

Answer Key

Part 1

1. 7 females, 1 male
2. Squid
3. As large as his hand
4. Answers will vary, but should suggest that they are the only hard, and therefore indigestible, parts of a squid
5. About three miles south of Point Pinos
6. (a.) The sea lions were supposedly killing and feeding upon the fish; (b) salmon
7. About twelve miles south of Monterey Bay, between Point Carmel and the lighthouse
8. Fish, or at least scales and bones; squid
9. They sometimes caught salmon with pieces bit out of them
10. No, he did not.

Part 2

1. 

2. Yes, positive. The line is almost straight; it goes up and to the right.
3. Yes
4. Hake
5. Sardine
6. Answers will vary but should indicate a negative effect on her pup since squid is lower in both calories and fat per gram
7. (a.) 0.0874, (b.) -0.066
8. 0.072
9. Its plot point is above the line of best fit/linear equation, which means herring is even higher in fat per gram and makes it an excellent choice
10. Yes, because it is a 1, which means there is a strong, positive correlation

Part 3: With 500 pounds of fish set as a parameter, the recipe can be made 333.33 times. Exact prices will vary depending on each student's own research. In general, the cost of the recipe as written is about $10.00; therefore, the total budget will be over $3,000.00.

GEORGIA AQUARIUM

Name Class Date

Pier 225: Now Serving Fish Smoothies!

Student Activity

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***Terms to Know**: calcium gluconate, chitin, correlation, deem, forage, lactase, lecithin, malnourished, mortality, non-profit, pinniped, wean*

Part 1

In the summer of 1899, Professor Lewis Lindsay Dyche traveled all the way from land-locked Lawrence, Kansas, to Monterey Bay, California. He spent four months studying California sea lions. He was interested in studying what the animals ate, as they were often targeted by local fisherman for stealing fish. Even today, sea lions arrive at rescue centers with gunshot wounds from fishermen who believe sea lions take their catch. This account of Dyche's research was published in 1902. Read the excerpt and answer the questions that follow.

Name Class Date

No. 1. June 25. Found old sea lion cow dead on beach near Point Pinos [southernmost point between Monterey Bay and Pacific Ocean]. Examined the stomach and found that it was full of the flesh of small squids. Beaks, arms and the so-called "pens" [chitin-like, hard, internal shell] of the squids were common in the half-digested and half-decayed mass.

No. 2. June 27. Found a dead sea lion cow (bullet hole in her head) about one-half mile south of Point Pinos. Stomach full of squids, many of them in good state of preservation.

No. 3. June 27. This animal was found [near] No. 2. It was a two- or three-year-old bull. It had been dead for some time, as the hair was slipping. Stomach was full of the chewed-up arms of an octopus or devil-fish [ray].

No. 4. June 30. About two miles south of Point Pinos found carcass of old bull sea lion which had been washed upon the shore in a mass of seaweeds. …This animal had been dead some time. There was a bullet-hole in his skull. Dissection showed that its stomach was gorged with the flesh of a "giant squid," as the large squids (weighing from twenty to forty pounds) of that coast are called. There were pieces of [squid] flesh taken from the stomach as large as my hand.

No. 5. July 7. Found sea lion cow at Point Pinos. Had been washed ashore during the night. The only material found in the stomach was a few parts of squid beaks and a bunch half as large as one's fist of the pens from the backs of squids.

No. 6. July 9. Found a sea lion cow dead on the beach near "Seal Rocks," about three miles south of Point Pinos. Stomach was well-filled with the chewed-up parts of a giant squid.

Nos. 7 and 8. July 16. Found two sea-lion cows about a mile south of Point Pinos. Both had been feeding on giant squids. The stomach of one contained about two quarts, that of the other about a gallon, of the chewed-up flesh and arms of giant squids.

The above animals were all found within three miles of Point Pinos. They had been killed, as I was informed by the fishermen, because they were killing and feeding upon the fish, mostly salmon, that were, at this time of the year, coming into the bay…. Yet there was not a fish scale or bone detected in the stomach of any one of them.

On the 20th of July I established a camp about twelve miles south of Monterey Bay, between Point Carmel and the lighthouse. …During this time three animals—all cows—were found dead on the shore. Dissection showed that all had been eating squids. The salmon fishermen who were present when the stomachs of the sea lions were opened up were very much surprised when they saw that the animals had been feeding upon squids. …The salmon fishermen told me that they sometimes caught salmon that had pieces bit out of them by sea lions. They showed me one such specimen. The cut was a smooth one, such as might have been made by a shark, but not a rugged tear, such as the large teeth of the sea lion would make.

1. Of the first eight sea lions Dyche dissected, how many were male and how many were female?

____

2. What kind food was found in most of the animals' stomachs?

____

3. How big were the pieces of squid that were found in the stomach of "No. 4," the old bull sea lion?

____

____

Name ____________________ Class __________ Date __________

4. Why do you think only the squids' beaks and pens were found in some of the sea lions?

5. Where was "Seal Rocks" located?

6. (a) According to the fishermen Dyche met, why were they killing the sea lions? (b.) For what kind of fish were the men looking?

7. Where did Dyche set up camp on July 20th?

8. What did the salmon fishermen expect to find inside the stomachs of the sea lions? What did they find instead?

9. What other evidence did the fishermen claim was proof that the sea lions were catching salmon?

10. Based on his research, do you think Dyche believed the salmon fishermen were justified in killing the sea lions?

Part 2

Research has advanced significantly since Dyche's investigation over a century ago, as has our understanding of the complex food webs flowing through the ocean. The recent unusual mortality events, or UMEs, that have stranded and killed thousands of sea lion pups on the shores of California inspired oceanographers, veterinarians and marine biologists to learn more about why these occur.

Scientists suspect climate changes and warming oceans are behind the UMEs. The high-fat-content fishes that sea lion mothers should eat while nursing prefer to live in cold water. When the ocean is too warm, some fish stay further out at sea. Nursing mothers either have to travel farther to get a good meal or eat something less nutritional close by. Compare the nutritional content of five forage fish commonly consumed by sea lions, including the squid encountered by Dyche.

Name ______________________ Class ____________ Date ____________

1. For each fish, create a scatter plot with the calories per gram on the x-axis and the total fat per gram on the y-axis. Use a separate piece of graph paper or enter the data into a spreadsheet program. After you plot the five points, draw a “line of best fit” on your scatter plot.

Forage fish	**Cal/gram**	**Total fat/gram**
Pacific sardine	2.17	0.124
Northern anchovy	1.31	0.048
Rockfish	0.94	0.016
Market squid	0.92	0.014
Pacific hake	0.9	0.013

2. Does your graph show any correlation between the calorie per gram and fat per gram in these five fish? If so, what kind? How do you know?

____

____

3. Do the forage fish with higher caloric contents also have higher fat contents?

____

4. Should a human who is concerned about caloric intake choose the northern anchovy or the Pacific hake for dinner?

____

5. Which fish is best for a mother sea lion that needs to produce milk with high fat content in order for her pup to grow?

____

6. Squid may be a suitable diet for most adult sea lions, but what about nursing mother sea lions? How might squid affect the health of her nursing pup if it is consumed as a primary food source? Why?

____

____

7. (a.) What is the slope (**m**) of the line formed by graphing the data? (b.) Now solve for **b** to find the linear equation for the line in your graph: y = mx + b. If the line was extended, where would it cross the y-axis?

____

____

8. The staff at Georgia Aquarium feed the sea lions a variety of restaurant-quality, sustainable fish including two different types of herring, capelin and squid. Based on the linear equation in #7, if herring has 1.58 calories per gram, what would you expect its fat content to be?

____

Name ______ Class ______ Date ______

9. During rehabilitation, rescue centers feed herring to recovering sea lions. It can be ground up in a fish smoothie for the newest patients or fed whole to those animals that are about to be released. Herring has 1.58 calories per gram and its actual fat content is 0.0904. Plot this fish on your graph. How would you rate herring (excellent, fair, or poor) as a food source for malnourished pinnipeds?

10. The correlation coefficient is a number between -1 and 1 that represents what kind of relationship there is between two sets of data, positive or negative, and how strong that relationship is. The closer the correlation coefficient is to zero, the less likely there is to be any connection between two data sets. The correlation coefficient for the forage fish data is 1. Does that match your response to question #2? Why or why not?

Part 3

California sea lion milk contains 22-44% fat. In order to produce that milk, mothers with nursing pups have specific dietary requirements that cannot always be met by the prey available. The longer the mothers are away from their pups while searching for food, the weaker the baby sea lions become. Pups can wean too early and wash ashore or wander off in search for food. When malnourished sea lions arrive at rescue centers in California, many are severely underweight. Pups who should be over 50 pounds often weigh less than half that. Luckily for these sea lions, the humans caring for them have been perfecting a recipe for fish smoothies.

The essence of a fish smoothie is herring pureed with water, vitamins, oil and a milk replacer that supplies enough fat, protein and essential nutrients for growing pups. Thousands of hungry, young sea lions can run up quite a grocery bill! Research the costs of the ingredients in the sea lion fish smoothie recipe below. While the type, amount and frequency of food each animal receives varies depending on age, body condition and specific medical problem, a rescue center can easily go through over 1,000 pounds of fish a day. Even if half that amount were used for older sea lions capable of eating whole fish, it would still leave 500 pounds of fish to be pureed for the pups.

How do you turn 500 pounds of herring into high-quality sea lion pup food? As you shop for ingredients online based on the fish smoothie recipe below, you will discover that pinnipeds have many of the same nutrition requirements as humans. Design a budget to determine how much money a non-profit rescue center needs in order to keep its pup population fed during a busy UME day. Caring for baby sea lions takes a lot more than a love for cute animals as you will see when you convert and calculate all the units needed to keep these pups fed!

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Name Class Date

To simplify your plan, begin by finding out how many times per day the recipe needs to be made to account for the 500 pounds of fish. (Hint: 1 kg = 2.2 lbs.)

Recipe ingredients	Recipe amount	Cost rate	Recipe cost	Daily amount	Daily cost
Fish	0.68 kg	$1 per pound	$1.50	500 lbs.	$500
Pedialyte®	300 ml				
Whipping cream	400 ml				
Salt	2 g				
Vitamin B1	200 mg				
Vitamin C	500 mg				
Vitamin E	400 IU				
Water	200 ml	$0	$0	0	$0
Lactase	0.75 ml to 1 qt whipping cream				
Calcium gluconate	280 mg				
Marine mammal multivitamin	1 capsule	$281 per 1000 capsules	$0.28	333	$93.57
Salmon oil	10 ml				
Lecithin	10 ml				
				Total Daily Budget	

Name Class Date

How do they do it? Many non-profit organizations rely on financial support from generous donors. Contact an animal rescue group in your community to investigate how they budget for the care and feeding of their animals.

Dr. Alexa McDermott (L), associate veterinarian at Georgia Aquarium, Dianne Cameron (C), marine mammal manager at Six Flags Discovery Kingdom, and Dennis Christen (R), senior director of zoological operations at Georgia Aquarium interact with the rescued sea lions as they prepare for their transport to Atlanta. (Georgia Aquarium/Tyler Andrews)

http://georgiaaquariumblog.org/georgia-aquarium-blog/2015/8/19/georgia-aquarium-rescues-stranded-california-sea-lions.html

Two of the Aquarium's sea lions, Neptune and Jupiter, were deemed non-releasable after stranding repeatedly during a recent unusual mortality event on the California coast.

http://georgiaaquariumblog.org/georgia-aquarium-blog/2015/12/11/name-reveal-sea-lion-pups.html

*The sea lion presentation in the **SunTrust Pier 225** gallery is called "Under the Boardwalk."*
http://news.georgiaaquarium.org/multimedia/album?id=57080ec96022747dda356ca7&t=photo&p=16&s=order

Science, Fine Arts

Chemistry, Earth Sciences, Visual Arts

Lesson Plan 4
Tropical Diver: Coral Chemistry

Teacher Instructions

When your students visit the **Tropical Diver** gallery at Georgia Aquarium, they will “dive” into one of the most diverse ecosystems in the world. The habitats and exhibits in this gallery provide views into the coral reefs of the Indian and Pacific Oceans. Your class will explore the ways a shipwreck becomes an artificial coral reef, watch garden eels sway in the current and become mesmerized by flowing, glowing jellies.

At the center of this colorful gallery is one of the largest living reef exhibits of any aquarium in the world, the Pacific Barrier Reef. Often called the “rainforests of the ocean,” coral reefs occupy only 1% of the marine environment and yet are home to over 25% of all marine life. They are disappearing at an alarming rate largely because of human behavior, such as water pollution and dangerous fishing practices.

Georgia Aquarium works with coral reef experts around the world—from Florida to Fiji—to help protect and regrow damaged reefs. Here in Atlanta, the Aquarium’s aquaculture laboratory cultivates corals for the Pacific Barrier Reef exhibit. Some of the jellies on display in **Tropical Diver** were also raised in the lab. These research and breeding programs align with the commitment of Georgia Aquarium to preserve biodiversity and support conservation efforts.

While scientists might debate the causes of climate change for the next millennium, ocean temperatures are warming and sea levels are rising. Ocean water is becoming more acidic and human activity is the largest factor. Bodies of water act like giant sponges, soaking up 30% to 40% of the carbon dioxide (CO_2) emitted as air pollution. Carbon dioxide dissolves in the water, but it doesn’t disappear. As CO_2 dissolves, the reaction lowers the pH level of the water and causes ocean acidification.

The experiment in this lesson plan highlights the effects of ocean acidification on coral reefs. Increased acidity interferes with photosynthesis and inhibits calcification. Both are critical. Calcification forms the skeleton upon which coral reefs grow and photosynthesizing algae feed many of the corals. The chain reaction in a tropical ecosystem’s food web can turn a previously thriving, diverse habitat into a barren patch of ocean floor. Once the coral disappears, so do all the organisms that make their homes on, under, around and in the reefs from microscopic plankton to apex predators like sharks.

The laboratory in Part 1 finds a new use for a familiar chemistry experiment with calcium carbonate and an acidic solution. It shows the forces at work behind ocean acidification and endangered coral reefs. The white chalk pieces must be traditional calcium carbonate chalk for blackboards and not chalk pens, pastels, dust-less, or sidewalk chalk. The buffer is the standard laboratory-grade solution available from scientific supply companies (like this one: www.carolina.com/catalog/detail.jsp?prodId=849693&s_cid=ppc_products&gclid=CLiurt274s0CFQqsaQodAiQBNQ). Make sure it is the pH 8 version, as it simulates seawater in the experiment.

In the second activity, students will learn about a very creative, and pH-neutral option to compensate for centuries of reef-damaging human activity. Artist Jason deCaires Taylor combines art and science to create underwater sculptures that become artificial reefs. What kind of sculpture would your students design for such a display? Perhaps Georgia Aquarium would be interested in adding sculptures to the Pacific Barrier Reef habitat some day! Extend the activity by enlisting your school's art department for students to sculpt 3-D models of their designs, cast in cement or fired in clay.

Answer Key

Part 1: Answers in the chart will depend on the exact volumes used in the experiment. Overall, the acidic vinegar will react the most with the chalk. The pH should be between 2.0 and 3.0. The neutral water and alkaline buffer solution will have little to no reaction.

1. Vinegar; it bubbled and the chalk started to disintegrate
2. Exact figures depend on the amount of the materials used, but it will be the chalk that went into the vinegar—if there is even enough of it left to weigh
3. $(CH_3COO)_2Ca + CO_2 + H_2O$; the products are calcium acetate, carbon dioxide and water
4. The bubbles, carbon dioxide; the white particulate, calcium acetate
5. The buffer solution, nothing
6. $CO_2 + H_2O \rightleftharpoons H_2CO_3$
7. $H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2$ or $C_2H_2CaO_6$
8. Answers will vary but will probably involve the substance being washed away or dissolving in the water
9. Answers will vary, but should reflect that their shells and homes will be smaller, weaker, thinner
10. Answers will vary and might include changing the temperature of the water or salinity of the water, or using an acidic solution with a higher or lower pH

Part 2: Students should answer all questions in writing and submit with their sketches.

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GEORGIA AQUARIUM

Name Class Date

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Student Activity

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In the second activity, you will learn about a very creative, and pH-neutral option to compensate for centuries of reef-damaging human activity. One artist combines art and science to create underwater sculptures that become artificial reefs. What kind of sculpture would you design for such a display? Perhaps Georgia Aquarium would be interested in adding sculptures to the Pacific Barrier Reef habitat some day!

Terms to Know: *aggregate, apex, calcification, compensating, conch, emit, inhibit, maquette, marine, particulate, polyp, secrete, substrate*

Name Class Date

Part 1

The pH of the ocean stayed around 8.3 (slightly alkaline) for hundreds of millions of years. The rise in surface water acid levels only began with the Industrial Revolution, two centuries ago. In that short amount of time, ocean acidification has wreaked havoc on marine ecosystems around the world and has caused ocean pH to drop by one tenth to 8.2. Coral reefs are located in the seas of more than 100 countries, but 93 of those countries already have damaged reefs. Acidification is only one of many threats to coral reefs, but it is the one that every person can help by reducing carbon footprints and limiting CO_2 emissions.

This experiment demonstrates the effects of alkalinity on calcium carbonate—the basis of coral growth. Acetic acid in the vinegar simulates the effects of increasing carbonic acid levels in ocean water. The chalk is a form of calcium carbonate. After a hard coral polyp attaches itself to a substrate, it secretes a substance that hardens into its skeleton of calcium carbonate ($CaCO_3$). The aggregate reef grows slowly as other corals attach to the existing skeleton and add to it. It can take up to 10,000 years for a small coral reef to form.

Materials

- 3 clear plastic cups of the same size
- 3 pieces of white chalk of equal size
- 3 litmus paper test strips
- Distilled white vinegar
- Distilled water
- Buffer solution
- Gram scale
- Timer or clock with minute hand
- Paper towels

Procedure

1. Label the cups with the three liquids: vinegar, water and buffer solution.
2. Use the litmus strips to test the pH of each solution. Record their levels in the chart below and identify each one as acid, base and/or neutral, based on the results.
3. Assign one piece of chalk to each cup. Keep track of which piece of chalk goes into which cup. You will be comparing the mass of the chalk before and after the experiment.
4. Weigh each piece of chalk on the scale and record its mass.
5. Pour an equal amount of each solution into its labeled cup. There should be enough to cover the chalk when it is added in the next step.
6. Place one piece of chalk in each cup. The chalk should be fully submerged.
7. In the space provided on the chart, record your observations of the initial reaction between the chalk and the solutions.
8. After three minutes, remove the pieces of chalk and place them on the paper towels to dry. Label the towels so you know which chalk was in which solution.
9. Record observations of any new or remaining particulates in each cup.
10. After the chalk has dried, weigh each one and record its mass.

GEORGIA AQUARIUM

Name ________________ Class ________ Date ________

	Vinegar	Water	Buffer
pH			
Mass of chalk, before			
Reactions			
Mass of chalk, after			
Particulates and observations			

1. Which solution had the most visible reaction with the chalk? What happened?

____

____

____

2. What were the changes in mass for each piece of chalk? Which one lost the most mass?

____

____

____

3. A solid, a gas and a liquid are formed when acetic acid (CH_3COOH) and calcium carbonate ($CaCO_3$) combine. Balance the equation and identify the products of the reaction:

$$CaCO_3 + 2CH_3COOH \rightarrow \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

____

____

____

4. Describe the evidence that indicated a chemical reaction was taking place. Which product or products caused these reactions?

____

____

____

Name ______________________________ Class ______________ Date ______________

5. Today, the pH of ocean water is around 8.1. Which solution represents sea water in this experiment? What happened to the chalk in this solution?

____
____
____

6. The culprit in ocean acidification is carbonic acid, not the acetic acid found in vinegar. Carbonic acid forms when ocean water absorbs and dissolves carbon dioxide. Balance the equation for carbonic acid:

$$CO_{\square} + H_{\square}O \rightleftharpoons H_{\square}CO_{\square}$$

7. Instead of the calcium acetate you saw in your experiment, calcium bicarbonate forms when carbonic acid combines with calcium carbonate ($CaCO_3$) in a coral reef. This reaction takes calcium from the corals' skeletons, thus dissolving and removing a primary ingredient in reef building. This is a form of chemical weathering, similar to how caves form in limestone (which is also a form of calcium carbonate). Based on your answer for carbonic acid in #6, balance the equation below for calcium bicarbonate.

$$H_{\square}CO_{\square} + CaCO_3 \rightarrow \underline{\hspace{6cm}}$$

8. What do you think happens to the calcium bicarbonate created when carbonic acid reacts with the coral reef?

____
____
____

9. Animals with shells like clams, oysters and conchs are called "calcifiers" because they also need calcium carbonate. What effect do you think the increased acidity of the ocean has on them?

____
____
____

10. What other variables could you add or alter in this experiment to see what effect, if any, those factors have on calcium carbonate?

____
____
____

Name Class Date

Part 2

An artificial reef is an underwater structure made by humans that supports marine life. Some are unintended, like the base of an oil rig at sea or a shipwreck. Artificial reefs have been made out of everything from old tires to subway cars to concrete pipes. The success of an artificial reef depends on the materials used to make it. Will it do more harm than good? The substrate should not come loose during a storm and crash into real coral reefs or leach poisons into the water.

One artist has a beautiful and promising alternative. Jason deCaires Taylor combines art with science to create large, underwater sculptures that evolve into artificial reefs. Taylor casts his statues in cement that already contains calcium carbonate so it is conducive to growing coral. He uses an environmentally-friendly mixture of concrete, sand, silica and other additives to render the statue pH neutral. Once a statue is cast and cured, it is lowered by boat into its chosen spot. His underwater sculpture museums continually transform as they become fully-functional artificial reefs.

Visit his website, www.underwatersculpture.com/sculptures, to see a gallery of Taylor's projects. His subjects and themes are as unique and stunning as the marine organisms that eventually call them home. Taylor has inspired other artists to create similar projects. If you had the opportunity to create an underwater sculpture that would become an artificial reef, what would it be? On separate paper, answer these questions and sketch a 2D version of your sculpture, also known as a *maquette*.

1. What materials would you use? Why? How might they affect the tropical ecosystem in which they are placed?
2. Some of Taylor's topics reflect current events, like refugees fleeing on a raft (*The Raft of Lampedusa)*. Others are commentaries on modern society, like *The Lost Correspondent*, which reflects the swift evolution of technology. What will be your theme? Why?
3. Taylor casts many of his statues from molds of real people. If your work features a person, who is the inspiration?
4. How would you like people to feel when they view your art?
5. Would you want your sculpture to stand alone or be part of a group display? Why?
6. If your sculpture deteriorated underwater, would you want to repair it? Why or why not?
7. What challenges might you encounter during the actual creation of your sculpture?
8. At what depth would you place the sculpture? Who can see it? Should it only be accessible to SCUBA divers? What about snorkelers and glass-bottomed boats?
9. How will the structure encourage marine life on your artificial reef? For example, are there vertical surfaces for polyps to attach to or crevices where small fish can hide? Could an animal become trapped or entangled?
10. What is the title of your piece?

Mathematics, Science, Social Studies

Quantities, Statistics, Algebra, Earth Sciences, Life Sciences, Civics

Lesson Plan 5
Ocean Voyager: Take Out the Trash!

Teacher Instructions

At 6.3 million gallons, the **Ocean Voyager Built by The Home Depot** gallery at Georgia Aquarium is one of the world's largest indoor aquatic habitats. Some of the biggest animals in the Aquarium live here: the whale sharks (*Rhincodon typus*) and manta rays (*Manta sp. cf. birostris*). The living collection your students see in **Ocean Voyager** represents marine life found off six of the seven continents. Each species is carefully selected in order to thrive with the other species. While most of them are commonly found in Indo-Pacific waters, this collection of fish and invertebrates would never be found in such concentration anywhere else in the world. Together, they highlight the Aquarium's dedication to raising awareness about the condition of all our world's oceans.

With 4,574 square feet of windows and a 100-foot-long underwater tunnel, students will have plenty of opportunities to view the thousands of animals in the **Ocean Voyager** habitat, including Tank, the 450-pound green sea turtle (*Chelonia mydas*). Tank came from the Aquarium's partner facility in Florida, Marineland Dolphin Adventure. Tank was rescued and rehabilitated after a shark attack. He now serves as an ambassador for his species, educating everyone about green sea turtles and the dangers all sea turtles face. Endangered sea turtles like Tank are especially vulnerable to marine debris. In fact, all seven species of sea turtles are affected by the entanglement and ingestion of trash that has found its way into oceans around the world.

Marine mammals around the world are threatened by marine debris, including several species found at Georgia Aquarium such as the California sea lion, harbor seal, southern sea otter, beluga whale and bottlenose dolphin. Often, the dangers are obvious. A dolphin's snout becomes trapped in the plastic loop from a six-pack of beverage cans. A sea lion has old fishing line wrapped tightly around its neck. A whale's fins are entangled in discarded fishing nets and ropes. A sea turtle mistakes a plastic bag for one of its favorite snacks - jellies. Marine debris that appears invisible also causes immense damage. Fish and crustaceans mistake trash for food and ingest garbage that starts out small, such as plastic microbeads, or as parts of larger objects that disintegrated into smaller pieces over time. Toxins enter the food web and bioaccumulate as larger species consume smaller species. Eventually, we eat seafood laced with chemical pollutants. Time to take out the trash!

The sheer volume of garbage found in our oceans is hard to comprehend. Marine debris is pulled into massive rotating whirlpools called "gyres." There are five major ocean-wide gyres that collect billions of tons of waste. These garbage patches are so large and reach so deep into the water column that scientists can't even agree on how to accurately measure them! Some of the debris floats, some of it sinks and some of it is too small to see. Where does it all come from? In this lesson plan, your students will analyze data on the single most frequent type of marine debris—plastic—and "think globally, act locally" by designing a marine debris awareness campaign specific to your school and community.

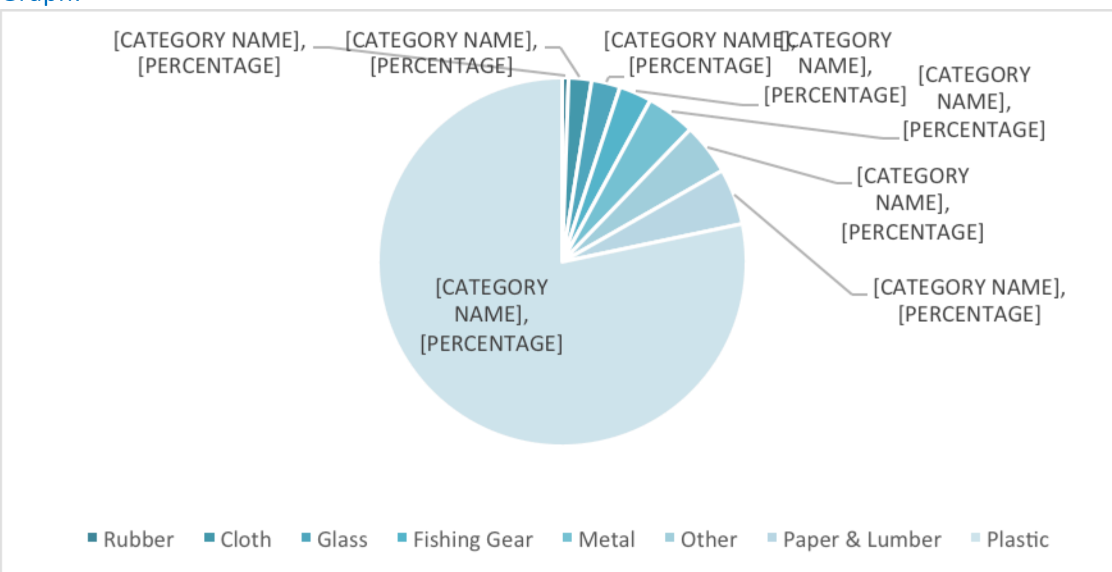
Answer Key

Part 1

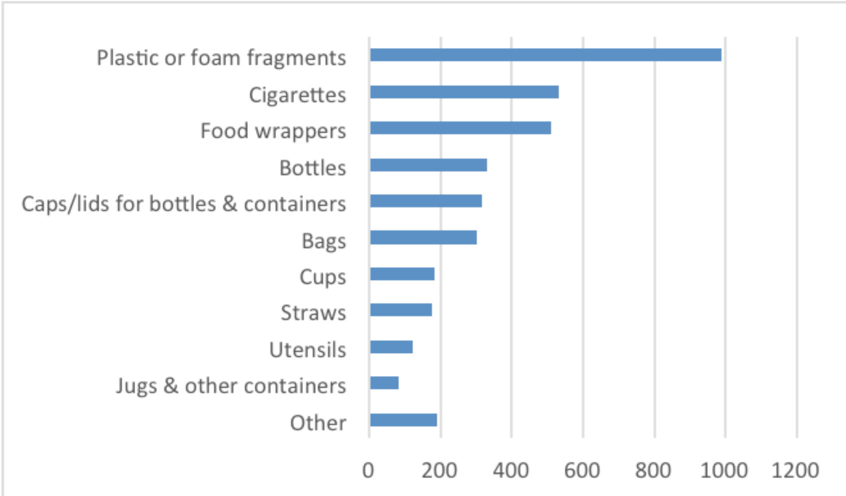
1. Chart:

Materials	# of Items	%
Rubber	27	1%
Cloth	96	2%
Glass	120	3%
Fishing Gear	136	3%
Metal	204	4%
Other	215	4%
Paper & Lumber	235	5%
Plastic	3732	78%

2. Graph:



3. Plastic
4. Yes, 78% is between 70% and 80%
5. (a.) 1,033:3732 = 1:3.6; (b.) True because 3.6 rounds to 4.
6. Answers will vary and may include
    a. Rubber: flip flops, tires
    b. Cloth: towels, clothing
    c. Glass: jars, bottles
    d. Fishing gear: buoys, nets
    e. Metal: cans, bottle caps
    f. Paper and lumber: cardboard, wood pallets

7. 

8. Plastic or foam fragments; 26.5%
9. Fishing gear
10. Answers may vary and can include food wrappers, bottles, caps/lids, bags, cups, straws, utensils, balloons, gloves, etc.

Name Class Date

Ocean Voyager: Take Out the Trash!

Student Activity

At 6.3 million gallons, the **Ocean Voyager Built by The Home Depot** gallery at Georgia Aquarium is one of the world's largest indoor aquatic habitats. Some of the biggest animals in the Aquarium live here: the whale sharks (*Rhincodon typus*) and manta rays (*Manta spp.*). The living collection you see in **Ocean Voyager** represents marine life found off six of the seven continents. Each species is carefully selected in order to thrive with the other species. While most of them are commonly found in Indo-Pacific waters, this collection of fish and invertebrates would never be found in such concentration anywhere else in the world. Together, they highlight the Aquarium's dedication to raising awareness about the condition of all our world's oceans.

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***Terms to Know**: bioaccumulate, ghost fishing, gyre, ingestion, utensils*

GEORGIA AQUARIUM

Name ________________ Class ________ Date ________

Part 1

Georgia Aquarium encourages individuals to become part of the pollution solution through its support of the Marine Debris Tracker (www.marinedebris.engr.uga.edu). This mobile app allows people all over the world to submit to a central database their observations of marine debris along with their efforts to remove it. The data sample below comes from just ONE month of voluntary reports to the debris tracker and includes litter from all continents, even Antarctica!

1. Calculate the percentage of the total for each type of marine debris listed in this chart.

Materials	**# of Items**	**%**
Rubber	27	
Cloth	96	
Glass	120	
Fishing Gear	136	
Metal	204	
Other	215	
Paper & Lumber	235	
Plastic	3732	

2. On separate paper, or using a computer, create a circle graph to represent the data in the chart above.

3. Which material comprises the majority of marine debris in this data sample? ____________

4. According to the National Oceanic and Atmospheric Administration (NOAA), 80% of ocean pollution comes from land-based activities. (The other 20% is sea-based, such as cargo that has fallen off ships or lost fishing gear.) Of the land-based marine debris, experts predict between 70% and 80% is plastic. Does the data sample from the Marine Debris Tracker support that statistic?

____

5. (a.) What is the ratio of plastic to all other materials combined in the chart?

____

(b.) Is this statement true or false? *Our oceans contain almost four times as many plastic marine debris items as other types of debris materials.* ____________

6. Give an example of litter that might be found in the ocean for each of these categories:

a. rubber ____________
b. cloth ____________
c. glass ____________
d. fishing gear ____________
e. metal ____________
f. paper and lumber ____________

Name Class Date

7. The plastics category from this one month of data can be further broken down. The "Other" category includes balloons and/or string, six-pack rings, gloves, diapers, syringes, lighters and tobacco packaging, among other things. On separate paper, or using a computer, create a horizontal bar graph to depict this information.

Object	**# of Items**
Jugs and other containers	83
Utensils	122
Straws	176
Cups	183
Bags	301
Caps/lids for bottles and containers	316
Bottles	331
Food wrappers	509
Cigarettes	531
Plastic or foam fragments	988
Other	192

8. What item (or items) makes up the majority of the plastic counted during this one month? What percentage of all the plastic is it?

9. Revisit the list of marine debris items in #1, above. The plastic items in the database are specifically land-based. However, which other category has items that could be included in a count of plastic debris?

10. List at least three plastic items from the chart in #7, including those in the "Other" category, found in and around your school.

Name Class Date

Part 2

Even if you live nowhere near a beach, litter in your neighborhood can end up as marine debris. Storm drains, streams and tributaries, and major rivers all flow into an ocean eventually. Whether you are land-locked or not, there are many ways to help all species that live on, under, over and near the water.

Select one of the topics below to research and design a marine debris awareness campaign for your school or community.

1. **Educate: It's all connected!** Find the body of water or tributary closest to your school. Provide an illustrated map to identify the path a piece of litter would take from your area, through the watershed and river systems, all the way to a coastal environment.

2. **Demonstrate: Float or fly?** Conduct a series of experiments to demonstrate how any piece of plastic that is light enough to float (in a container of water) or fly (with the help of a fan) is likely to end up as marine debris. Remind your friends and neighbors why it is important for trash cans to have well-fitting lids when placed outside!

3. **Innovate: Find a solution**. Select one of the plastic items from Part 1 that is used commonly in your school cafeteria, such as straws or plastic bags. Provide data to explain how that item is a risk to marine life and suggest an alternative. Instead of buying bottled water, for example, convince your classmates to go fill reusable water bottles at the water fountains.

4. **Motivate: Contribute to the future.** Research a cutting edge solution for marine debris that is currently in the works. For example, one beverage company has developed a six-pack ring that feeds animals instead of strangling them! Select one you think has great potential. Convince your community to become involved either by publicizing their efforts or raising funds to support further development.

5. **Activate: Organize a clean-up effort**. Join forces with an organization in your community and select a location near your school that is in need of a neighborhood clean-up day. Collect or solicit donations for supplies. Advertise the event to sign-up volunteers. When you finish, provide a write-up along with before and after photographs to your local media.

6. **Create: Environmental art.** Collect recyclable items from your school that might otherwise end up as marine debris or in a landfill. Use them to create an art sculpture to draw attention to these "disposable" items that live on long after we are finished with them. For inspiration, check out *Washed Ashore: Art to Save the Sea* (www.washedashore.org), an art exhibition that visited Georgia Aquarium for this very purpose.

Name Class Date

Crossword: Animal Collectives

We've all heard of a school of fish but what about a troupe of shrimp? The word "swarm" may bring a group of bees to mind, but did you know it is also used for a completely unrelated species? Many of the marine and freshwater animals you see at Georgia Aquarium have specific terms to describe their collective groups, but you may not have heard of some of them. Would you shiver if you came across a shiver in the ocean? Would you want to romp with a romp?

In the crossword puzzle below, the clues are the names used to describe collective groups of animals found at Georgia Aquarium. To complete the puzzle on the next page, fill in the singular noun for the animal they describe. A word bank is provided.

Across

1. cast
3. shoal
5. romp
7. hover
11. colony
12. swarm
13. fever
14. pod
15. shiver

Down

2. congregation
4. battery
6. bale
8. bed
9. smack
10. army
13. rookery

Word Bank

ALLIGATOR	OTTER
BARRACUDA	PENGUIN
BASS	SEAL
CRAB	SHARK
DOLPHIN	STINGRAY
EEL	TROUT
FROG	TURTLE
JELLIES	URCHIN

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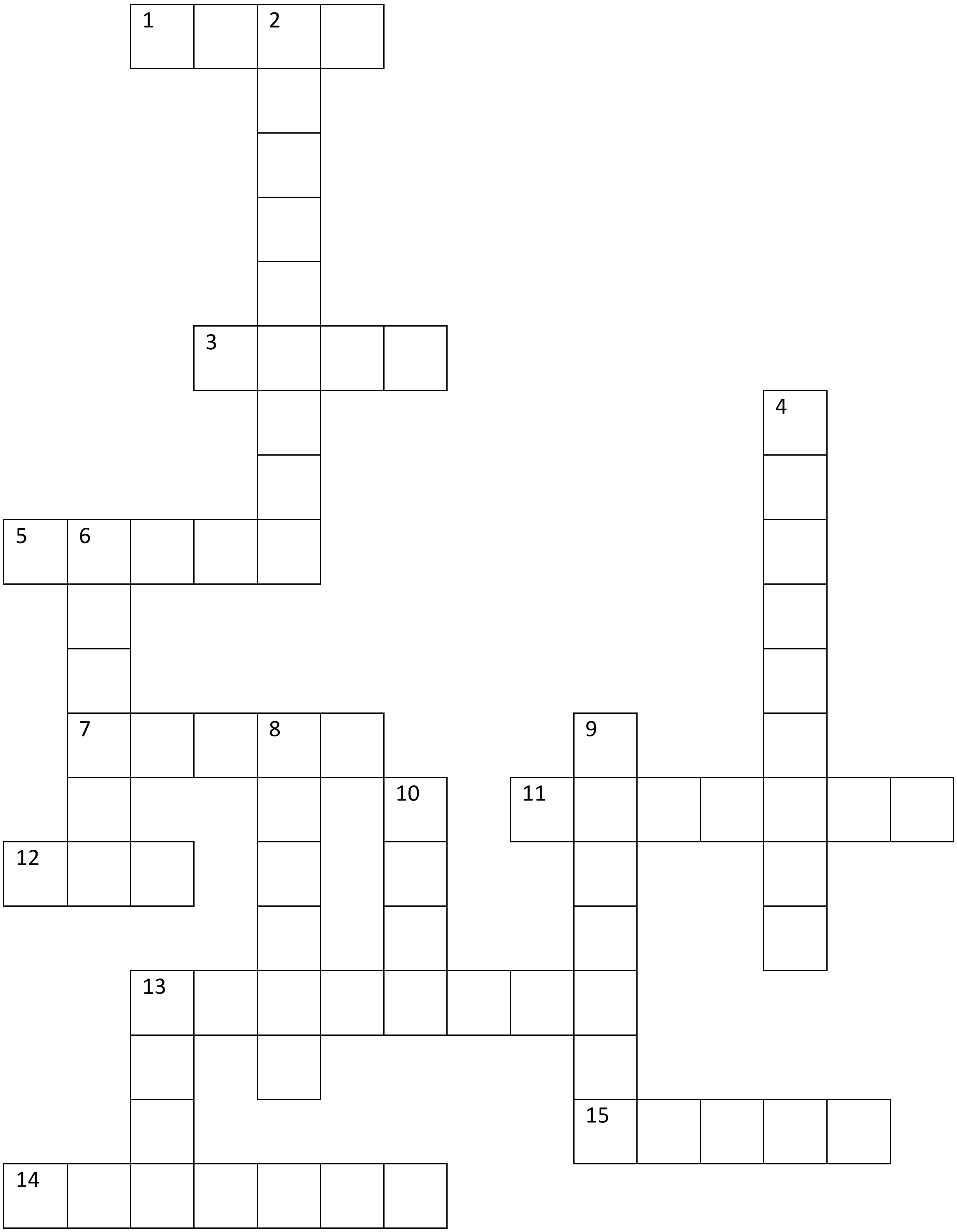

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Name ______________________ Class ____________ Date ____________

Word Search: Oceans, Seas, Bays, and Gulfs

An **ocean** is one of the five major bodies of salt water that surround the continents. A **sea** is a division of an ocean or a large body of salt water mostly enclosed by land. **Gulfs** and **bays** are bodies of water that jut into the land; a **gulf** is larger, sometimes has a narrow mouth and is almost completely surrounded by land. Search below for the names of these four oceans, four seas, two bays and two gulfs.

Gulf of ALASKA
ARCTIC Ocean
ATLANTIC Ocean
BERING Sea
CARIBBEAN Sea
HUDSON Bay

INDIAN Ocean
MEDITERRANEAN Sea
Gulf of MEXICO
MONTEREY Bay
PACIFIC Ocean
RED Sea

M	J	F	I	L	G	C	A	L	C	O	H	A	T
G	E	M	A	N	L	T	I	W	A	Z	D	L	E
B	F	D	I	R	L	R	D	F	R	I	K	A	D
V	N	R	I	A	C	L	L	D	I	A	C	S	P
V	E	Y	N	T	W	T	B	N	B	C	J	K	R
B	O	T	E	K	E	J	I	W	B	Z	A	A	N
H	I	X	R	W	O	R	S	C	E	N	Z	P	A
C	R	C	U	O	B	R	R	A	A	G	F	C	I
Y	E	R	E	T	N	O	M	A	N	E	Z	Q	D
F	X	E	S	F	Q	T	K	T	N	H	W	P	N
N	D	Q	R	M	E	X	I	C	O	E	U	Y	I
G	B	P	E	U	W	J	N	K	F	G	A	X	T
B	H	U	D	S	O	N	E	I	T	L	F	N	K

Answers are Questions: Aquarium Jeopardy!

- Point values in ascending order from 100-500
- Answers must be in the form of a question

Water	Elasmobranches	Life History	Physiology	Georgia Aquarium	Conservation
The percentage of the Earth's water that is fresh water	The protective covering over sharks' skin	The name of the southern super continent after the Pangaea split	One challenge faced by organisms in the intertidal zone	The Correll Center for Aquatic Animal Health was created in this year	The reason a species would be a non-sustainable seafood choice
The depth at which colors begin to disappear	The shark to which the largest shark tooth fossil belongs	The currently accepted approximate age of the Earth	The primary source of fresh water for marine mammals	The amount of water in Ocean Voyager	A natural substance that can be used in place of fossil fuels to make plastic
The ideal water temperature for coral reefs	The common name for *Rhincodon typus*	The era to which the earliest animal fossils can be dated	An adaptation found in mangroves allowing them to grow directly in seawater	The name of the species of penguin found at Georgia Aquarium	The number of years it takes for a plastic grocery bag to decompose
The salinity of ocean water	A difference between sharks and rays	The oldest region on the world ocean (which "ocean")	Adaptations in the gills of bony fish allowing them to live in fresh water	The name of Georgia Aquarium's first manta ray	Pollution resulting from the actions of the general population
The temperature of the water in the deepest areas of the ocean	One of the differences between skates and rays	The number of years (in millions) that horseshoe crabs have been on Earth	The process that follows glycolysis when oxygen is not present	The smallest species of shark found in Georgia Aquarium	The characteristics of amphibians that make them indicator species

Alternate questions:

- Name three species of rays found in the Seaside Touch Pool. *(black blotched fantail, cownose, Atlantic)*
- What is the conservation status of the California sea lion on the IUCN Red List? *("Least Concern")*
- How long have sharks remained unchanged? *(420 billion years)*

Final Jeopardy Category: Research and Conservation

- The complete name of the Georgia Aquarium's "4R Program" designed to positively impact the health and well-being of aquatic life from around the world.
  (Rehabilitation, Responsibility, Rescue and Research)

Answer Keys

Crossword Puzzle

Across
1. cast: CRAB
3. shoal: BASS
5. romp: OTTER
7. hover: TROUT
11. colony: PENGUIN
12. swarm: EEL
13. fever: STINGRAY
14. pod: DOLPHIN
15. shiver: SHARK

Down
2. congregation: ALLIGATOR
4. battery: BARRACUDA
6. bale: TURTLE
8. bed: URCHIN
9. smack: JELLIES
10. army: FROG
13. rookery: SEAL

Word Search

M	J	F	I	L	G	C	A	L	C	O	H	A	T
G	E	M	A	N	L	T	I	W	A	Z	D	L	E
B	F	D	I	R	L	R	D	F	R	I	K	A	D
V	N	R	I	A	C	L	L	D	I	A	C	S	P
V	E	Y	N	T	W	T	B	N	B	C	J	K	R
B	O	T	E	K	E	J	I	W	B	Z	A	A	N
H	I	X	R	W	O	R	S	C	E	N	Z	P	A
C	R	C	U	O	B	R	R	A	A	G	F	C	I
Y	E	R	E	T	N	O	M	A	N	E	Z	Q	D
F	X	E	S	F	Q	T	K	T	N	H	W	P	N
N	D	Q	R	M	E	X	I	C	O	E	U	Y	I
G	B	P	E	U	W	J	N	K	F	G	A	X	T
B	H	U	D	S	O	N	E	I	T	L	F	N	K

(Over, Down, Direction)
ALASKA (13, 1, S)
ARCTIC (4, 2, SE)
ATLANTIC (8, 1, SW)
BERING (1, 6, NE)
CARIBBEAN (10, 1, S)
HUDSON (2, 13, E)
INDIAN (14, 11, N)
MEDITERRANEAN (1, 1, SE)
MEXICO (5, 11, E)
MONTEREY (8, 9, W)
PACIFIC (13, 7, NW)
RED (4, 11, S)

Aquarium Jeopardy

What is/are…?

Water	Elasmobranches	Life History	Physiology	Georgia Aquarium	Conservation
3%	Dermal denticles	Gondwana	Extreme temperature changes, water vs. air cover, salinity, waves	2006	Consumed faster than they can reproduce/farming methods harmful to environment
30 ft.	Megalodon	4.5 billion years	Food	6.3 million gallons	Corn
77°F or 25°C (answer can vary by a degree)	Whale shark	Precambrian	Salt excretion on leaves, "sacrificial leaf"	African	60
3.5% or 35 ppt (answer may vary from 33-36ppt/3.3-3.6%)	Placement of gill slits	Indo-Pacific	Ion pumps	Nandi	Non-point source pollution
4°C or 39°F	Spines, extra set of fins, lay eggs/live birth	350 million (accept 300-450 million)	Fermentation	Epaulette shark	Absorption of contaminants through skin (population levels indicate pollution levels)

Go Figure!

Teachers: Let numbers (and maybe a little math) tell the story of Georgia Aquarium to your students. Swim around this list to locate information you can use as reference material in your classroom. *Note*: Information is subject to change.

PEOPLE

- More than **24 million** guests have visited Georgia Aquarium since it opened in 2005.
- Guests from all **50 states** and **143 countries** on **six continents** have visited the Aquarium.
- Volunteers have served more than **1.6 million** hours since 2005.

SIZE

- **One-and-a-half White Houses** could fit into the 84,000 square-foot AT&T Dolphin Tales gallery.
- The Dolphin Tales Theater's impressive viewing window is the length of **two school buses**.
- Georgia Aquarium is one of the world's largest aquariums with more than **10 million gallons** of water in more than **100 habitats**.
- Tropical Diver's Pacific Barrier Reef habitat is one the largest reef exhibits in the United States, at about **164,000 gallons**.
- Georgia Aquarium is the only aquarium in the United States that is home to manta rays and the only aquarium outside of Asia that is home to whale sharks, the **largest fish** in the world.
- Ocean Voyager is one of the world's largest indoor aquatic habitats at **6.3 million gallons**.

FOOD (Per Year!)

- Georgia Aquarium's commissary prepares more than **600,000 pounds** (272,158 kg) of food for its animals.
- Collectively, the four whale sharks in Ocean Voyager eat more than **91,500 pounds** (41,504 kg) of krill, fish and gel.
- Penguins are offered **18,500 pounds** (8,391 kg) of diet items.
- Beluga whales are offered more than 70,000 lbs (31, 751 kg) of fish.
- Sea otters are offered more than 18,500 lbs (8,391 kg) of clams, squid, crab, shrimps, scallops and other assorted seafood.
- The commissary handles enormous amounts of seafood including **76, 500 pounds** (34,700 kg) of krill, **250,000 pounds** (113,399 kg) of capelin, and **8,700 pounds** (3,946 kg) of fish-based gel.

WATER

- Each minute, the Aquarium's life support system filters more than **170,000 gallons** of water.
- The building uses about **70 miles** of pipes...enough to circle the city of Atlanta along I-285.
- Georgia Aquarium's Life Support Systems are able to recover and reuse **99.5%** of all exhibit water each week.
- Georgia Aquarium has **reduced water usage by about 24%** each month through a combination of condensation recaptured from cooling units, waterless urinals and operational improvements to life support systems.

Aquarium Awareness Days

This month-by-month list includes key dates that readily connect your students to the STEAM themes found within Georgia Aquarium. Be creative, have fun—go deep!

For example,

- For African Penguin Awareness Day in October, research the *MV Treasure* Oil Spill. Morty Waddlesworth, the elder statesman of the Aquarium spokespenguin family, is a survivor of this historic event.
- Ask students to compare the effects of climate change and the environmental characteristics of the North Pole to their hometown for International Polar Bear Day, February 27.
- On World Oceans Day in June, make a school-wide commitment to take a pass on disposable bottles, utensils and wrappers, as these items often end up as plastic trash in our ocean.

Note: Dates in **bold** are observed at Georgia Aquarium

January
- **17: National Dolphin and Whale Protection Awareness Day**
- **20: Penguin Awareness Day**

February
- 2: World Wetlands Day
- 14: World Whale Day
- 27: International Polar Bear Day

March
- 3: World Wildlife Day
- 22: World Water Day
- 28: Earth Hour

April
- 16: Dolphin Day
- **17: Autism Awareness Day**
- **22: Earth Day**
- 25: World Penguin Day

May
- **16: Endangered Species Day**
- **21: Armed Forces Day**
- 22: World Biodiversity Day
- 23: World Turtle Day

June
- 5: World Environment Day
- **8: World Oceans Day**
- 24: Catfish Day

July
- 14: Shark Awareness Day
- 16: World Snake Day

August
- **30: International Whale Shark Day**

September
- **18: Sea Otter Awareness Week**
- 18: World Water Monitoring Day
- 27: World Rivers Day

October
- 4: World Animal Day
- 5: World Habitat Day
- 8: World Octopus Day
- **8: Cephalopod Awareness Days**
- **13: African Penguin Awareness Day**
- 21: Reptile Awareness Day

November
- 3: Jellyfish Day

Deeper Dive: Curriculum Correlations
Grades 9-12

We know how important it is for you to justify field trips and document how instructional time is spent outside of your classroom. With this in mind, both the activities in this Teacher's Guide and the experiences your students have during their field trip to Georgia Aquarium are correlated to the Common Core State Standards for Mathematics, Common Core State Standards for English Language, the Next Generation Science Standards, the C3 Framework for Social Studies State Standards, and the National Core Arts Standards. These standards are arranged by content area and then by grade.

Following the national curricula, you will find the Georgia Performance Standards and Standards of Excellence. In addition, specific requirements are provided for Alabama, Florida, North Carolina, South Carolina, and Tennessee.

NATIONAL STANDARDS

Common Core State Standards for Mathematics
Standard for Mathematical Practice: CCSS.Math.Practice.MP1, CCSS.Math.Practice.MP2, CCSS.Math.Practice.MP4, CCSS.Math.Practice.MP5, CCSS.Math.Practice.MP6
Number and Quantity: CCSS.Math.Content.HSN.Q.A.1, CCSS.Math.Content.HSN.Q.A.2, CCSS.Math.Content.HSN.Q.A.3
Algebra: CCSS.Math.Content.HSA.SSE.A.1, CCSS.Math.Content.HSA.CED.A.1, CCSS.Math.Content.HSA.REI.B.3
Statistics and Probability: CCSS.Math.Content.HSS.ID.A.1, CCSS.Math.Content.HSS.ID.B.6, CCSS.Math.Content.HSS.ID.C.7, CCSS.Math.Content.HSS.ID.C.8, CCSS.Math.Content.HSS.IC.A.2

Common Core State Standards for English Language Arts
Reading: Informational Text
- Grades 9-10: CCSS.ELA-Literacy.RI.9-10.1
- Grades 11-12: CCSS.ELA-Literacy.RI.11-12.1

Writing
- Grades 9-10: CCSS.ELA-Literacy.W.9-10.7, CCSS.ELA-Literacy.W.9-10.8, CCSS.ELA-Literacy.W.9-10.9
- Grades 11-2: CCSS.ELA-Literacy.W.11-12.7 CCSS.ELA-Literacy.W.11-12.8, CCSS.ELA-Literacy.W.11-12.9

Speaking and Listening
- Grades 9-10: CCSS.ELA-Literacy.SL.9-10.1, CCSS.ELA-Literacy.SL.9-10.2, CCSS.ELA-Literacy.SL.9-10.4
- Grades 11-12: CCSS.ELA-Literacy.SL.11-12.1, CCSS.ELA-Literacy.SL.11-12.2, CCSS.ELA-Literacy.SL.11-12.4

Literacy in History/Social Studies
- Grades 9-10: CCSS.ELA-Literacy.RH.9-10.1, CCSS.ELA-Literacy.RH.9-10.4, CCSS.ELA-Literacy.RH.9-10.7, CCSS.ELA-Literacy.RH.9-10.9

- Grades 11-2: CCSS.ELA-Literacy.RH.11-12.1, CCSS.ELA-Literacy.RH.11-12.4, CCSS.ELA-Literacy.RH.11-12.7, CCSS.ELA-Literacy.RH.11-12.9

Literacy in Science and Technical Subjects

- Grades 9-10: CCSS.ELA-Literacy.RST.9-10.3, CCSS.ELA-Literacy.RST.9-10.4, CCSS.ELA-Literacy.RST.9-10.7
- Grades 11-12: CCSS.ELA-Literacy.RST.11-12.3, CCSS.ELA-Literacy.RST.11-12.4, CCSS.ELA-Literacy.RST.11-12.7

Next Generation Science Standards: HS-PS1-1, HS-PS1-2, HS-PS1-5, HS-PS1-7, HS-LS2-1, HS-LS2-2, HS-LS2-6, HS-LS2-7, HS-LS4-5, HS-LS4-6, HS-ESS3-4, HS-ESS3-6, HS-ETS1-1, HS-ETS1-2, HS-ETS1-3

C3 Framework for Social Studies State Standards: D1.5.9-12, D2.Eco.12.9-12, D2.Geo.2.9-12, D2.Geo.4.9-12, D2.Geo.6.9-12, D2.His.2.9-12, D3.1.9-12, D4.3.9-12, D4.6.9-12, D4.7.9-12

National Core Arts Standards: VA:Cr1.2.Ia, VA:Cr2.2.Ia, VA:Cr2.3.Ia, VA:Pr6.1.Ia

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GEORGIA

Mathematics

Standards for Mathematical Practice: 1, 2, 4, 5, 6
Number and Quantity: MGSE9-12.N.Q.1, MGSE9-12.N.Q.2, MGSE9-12.N.Q.3
Algebra: MGSE9-12.A.SSE.1, MGSE9-12.A.CED.1, MGSE9-12.A.REI.3
Statistics and Probability: MGSE9-12.S.ID.1, MGSE9-12.S.ID.6, MGSE9-12.S.ID.7, MGSE9-12.S.ID.8, MGSE9-12.S.IC.2

English Language Arts and Literacy

Grades 9-10: ELAGSE9-10RI1, ELAGSE9-10W7, ELAGSE9-10W8, ELAGSE9-10W9, ELAGSE9-10SL1, ELAGSE9-10SL2, ELAGSE9-10SL4, L9-10RH1, L9-10RH4, L9-10RH7, L9-10RH9, L9-10RST3, L9-10RST4, L9-10RST7
Grades 11-12: ELAGSE11-12RI1, ELAGSE11-12W7, ELAGSE11-12W8, ELAGSE11-12W9, ELAGSE11-12SL1, ELAGSE11-12SL2, ELAGSE11-12SL4, L11-12RH1, L11-12RH4, L11-12RH7, L11-12RH9, L11-12RST3, L11-12RST4, L11-12RST7

Science

Biology: SB4, SB5,
Chemistry: SC1f, SC2a, SC3, SC4a, SC6
Earth Systems: SES6
Ecology: SEC1, SEC2d, SEC3, SEC4c, SEC5
Environmental Science: SEV1, SEV2c, SEV2d, SEV4f, SEV5c, SEV5e
Oceanography: SO2, SO3, SO5, SO6c
Physical Science: SP3B, SPS6e, SPS10b
Physics: SP5b
Zoology: SZ3, SZ4, SZ5

Social Studies

World Geography: SSWG1b, SSWG5
Information Processing Skills: 6, 11, 12

Fine Arts
Visual Arts: VAHSVAMC.2, VAHSVACU.1a, VAHSVAPR.4, VAHSVAPR.5g, VAHSVAC.1a
Sculpture: VAHSSCPR.1, VAHSSCPR2d, VAHSSCC.1

ALABAMA

Mathematics
Standard for Mathematical Practice: 1, 2, 4, 5, 6
Algebra I: 4, 5, 6, 7, 12, 17, 41, 45, 46
Algebraic Connections: 1, 2, 5
Algebra II: 20

English Language Arts
Grade 9: 10, 26, 27, 28, 30, 31, 33
Grade 10: 10, 27, 28, 29, 31, 32, 34
Grade 11: 10, 25, 26, 27, 29, 30, 32
Grade 12: 10, 25, 26, 27, 29, 30, 32

Science
Biology: 7, 8, 10, 13,
Chemistry: 5, 6
Earth and Space Science: 13
Environmental Science: 3, 4, 6, 8, 10, 11, 12, 16
Physical Science: 1, 3, 4, 5, 10
Physics: 12

Social Studies
Contemporary World Issues and Civic Engagement: 8
Human Geography: 10

Arts Education
Visual Arts Level 1: 1, 2, 4, 5
Visual Arts Level 2: 1, 2, 5
Visual Arts Level 3: 1, 2

FLORIDA

Mathematics
Algebra: MAFS.912.A-CED.1.1, MAFS.912.A-REI.2.3, MAFS.912.A-SSE.1.1
Number and Quantity: MAFS.912.N-Q.1.1, MAFS.912.N-Q.1.2, MAFS.912.N-Q.1.3,
Statistics and Probability: MAFS.912.S-IC.1.2, MAFS.912.S-ID.1.1, MAFS.912.S-ID.2.6, MAFS.912.S-ID.3.7MAFS.912.S-ID.3.8
Mathematical Practice: MAFS.K12.MP.1.1, MAFS.K12.MP.2.1, MAFS.K12.MP.4.1, MAFS.K12.MP.5.1, MAFS.K12.MP.6.1

English Language Arts

Grades 9-10: LAFS.910.RH.1.1, LAFS.910.RH.2.4, LAFS.910.RH.3.7, LAFS.910.RH.3.9, LAFS.910.RI.1.1, LAFS.910.RST.1.3, LAFS.910.RST.2.4, LAFS.910.RST.3.7, LAFS.910.SL.1.1, LAFS.910.SL.1.2, LAFS.910.SL.2.4, LAFS.910.W.3.7, LAFS.910.W.3.8, LAFS.910.W.3.9

Grades 11-12: LAFS.1112.RH.1.1, LAFS.1112.RH.2.4, LAFS.1112.RH.3.7, LAFS.1112.RH.3.9, LAFS.1112.RI.1.1, LAFS.1112.RST.1.3, LAFS.1112.RST.2.4, LAFS.1112.RST.3.7, LAFS.1112.SL.1.1, LAFS.1112.SL.1.2, LAFS.1112.SL.2.4, LAFS.1112.W.3.7, LAFS.1112.W.3.8, LAFS.1112.W.3.9

Science

Earth and Space Science: SC.912.E.7.1, SC.912.E.7.8, SC.912.E.7.9

Life Science: SC.912.L.15.6, SC.912.L.15.7, SC.912.L.17.1, SC.912.L.17.14, SC.912.L.17.16, SC.912.L.17.17, SC.912.L.17.2, SC.912.L.17.20, SC.912.L.17.3, SC.912.L.17.6, SC.912.L.17.8, SC.912.L.17.9

Nature of Science: SC.912.N.1.1, SC.912.N.4.2

Physical Science: SC.912.P.10.14, SC.912.P.10.15, SC.912.P.8.11, SC.912.P.8.13, SC.912.P.8.5, SC.912.P.8.7

Social Studies

American History: SS.912.A.7.12

Civics and Government: SS.912.C.2.10, SS.912.C.2.5

Geography: SS.912.G.1.4, SS.912.G.3.1, SS.912.G.5.4SS.912.G.5.6, SS.912.G.6.5

Humanities: SS.912.H.1.5

World History: SS.912.W.1.3, SS.912.W.4.11

Visual Art: VA.912.C.1.7, VA.912.H.3.2, VA.912.H.3.3, VA.912.O.1.5, VA.912.S.3.1, VA.912.S.3.10

NORTH CAROLINA

Mathematics

Standards for Mathematical Practice: 1, 2, 4, 5, 6

NC Math I: NC.M1.N-RN.2, NC.M1.A-SSE.1, NC.M1.A-CED.1, NC.M1.A-REI.3, NC.M1.S-ID.1, NC.M1.S-ID.6, NC.M1.S-ID.7, NC.M1.S-ID.8

NC Math II: NC.M2.N-RN.1, NC.M2.N-RN.2, NC.M2.N-RN.3, NC.M2.A-SSE.1, NC.M2.A-CED.1, NC.M2.S-IC.2

NC Math III: NC.M3.A-SSE.1, NC.M3.A-CED.1

English Language Arts

Grades 9-10: RI.1, W.7, W.8, W.9, SL.1, SL.2, SL.4

Grades 11-12: RI.1, W.7, W.8, W.9, SL.1, SL.2, SL.4

Science

Physical Science: PSc.2.2.3, PSc.2.2.4, PSc.2.2.6

Biology: Bio.2.1.1, Bio.2.1.3, Bio.2.2.1, Bio.2.2.2, Bio.3.5.2

Chemistry: Chm.1.2.4, Chm.1.3.2, Chm.1.3.3, Chm.2.2.2, Chm.2.2.3, Chm.3.2.2

Physics: Phy.2.3.2, Phy.2.3.4

Earth/Environmental Science: EEn.2.2.1, EEn.2.4.2, EEn.2.6.4, EEn.2.7.3, EEn.2.8.4

Social Studies
World History: WH.H.5.1, WH.H.8.5
21st Century Geography: 12.G.1.1, 12.G.3.1, 12.G.3.4

Arts Education, Visual Arts: B.V.3.2, B.CX.1.5, I.V.3.2, I.CX.1.5, P.V.3.3, P.CX.1.5, A.V.3.1, A.CX.1.5

SOUTH CAROLINA

Mathematics
Mathematical Process Standards: 1, 2, 4, 5, 6
Algebra: ACE.1, AREI.3, ASE.1
Number and Quantity: NQ.1, NQ.2, NQ.3
Statistics and Probability: SPID.1, SPID.6, SPID.7, SPID.8

English Language Arts
English 1, 2, 3, 4: RI.5.1, C.1.1, C.1.2, C.2.1, C.3.2

Science
Biology: H.B.1A.2, H.B.1A.3, H.B.1A.4, H.B.1A.5, H.B.1A.6, H.B.1A.7, H.B.1B.1, H.B.6A.1, H.B.6A.2, H.B.6C.1, H.B.6D.1
Chemistry 1: H.C.1A.2, H.C.1A.3, H.C.1A.4, H.C.1A.5, H.C.1A.6, H.C.1A.7, H.C.1B.1, H.C.3A.2, H.C.5A.4, H.C.6A.4, H.C.7A.3
Physics 1: H.P.1A.2, H.P.1A.3, H.P.1A.4, H.P.1A.5, H.P.1A.6, H.P.1A.7, H.P.1B.1, H.P.3E.2, H.P.3E.3, H.P.3E.5
Earth Science: H.E.1A.2, H.E.1A.3, H.E.1A.4, H.E.1A.5, H.E.1A.6, H.E.1A.7, H.E.1B.1, H.E.3B.2, H.E.4A.7, H.E.6A.1, H.E.6A.5

Social Studies
World Geography: WG-2.6, WG-6.6
World History from 1300: MWH-8.7
Social Studies Literacy Skills for the Twenty-first Century:

- Represent and interpret Earth's physical and human systems using maps, mental maps, geographic models and other social studies resources to make inferences and draw conclusions.
- Analyze and draw conclusions about the locations of places, the conditions at places, and the connections between places.

Visual Arts
Level 1: VAH1-1.3, VAH1-6.2
Level 2: VAH2-1.3, VAH2-6.2
Level 3: VAH3-1.3, VAH3-6.2
Level 4: VAH4-1.3, VAH4-6.2

TENNESSEE

Mathematics
Standards for Mathematical Practice: 1, 2, 4, 5, 6
Number and Quantity: N-Q 1, N-Q 2, N-Q 3
Algebra: A-SSE 1, A-CED 1, A-REI 3
Statistics and Probability: S-ID 1, S-ID 6, S-ID 7, S-ID 8, S-IC 2

English Language Arts
Grades 9-10: RI.1, W.7, W.8, W.9, SL.1, SL.2, SL.4
Grades 11-12: RI.1, W.7, W.8, W.9, SL.1, SL.2, SL.4

Science
Biology I: CLE 3210.Inq.2, CLE 3210.Inq.3, CLE 3210.Inq.4, CLE 3210.T/E.1, CLE 3210.T/E.2, CLE 3210.T/E.3, CLE 3210.Math.2, CLE 3210.2.1, CLE 3210.2.2, CLE 3210.2.3, CLE 3210.3.1, CLE 3210.5.1
Biology II: CLE 3216.Inq.2, CLE 3216.Inq.3, CLE 3216.Inq.4, CLE 3216.T/E.1, CLE 3216.T/E.2, CLE 3216.T/E.3, CLE 3216.Math.2, CLE 3216.2.1, CLE 3216.2.2, CLE 3216.2.3, CLE 3216.6.1
Chemistry I: CLE 3222.Inq.2, CLE 3222.Inq.3, CLE 3222.Inq.4, CLE 3222.T/E.1, CLE 3222.T/E.2, CLE 3222.T/E.3, CLE 3222.Math.2, CLE 3221.1.2, CLE 3221.3.3
Chemistry II: CLE 3224.Inq.2, CLE 3224.Inq.3, CLE 3224.Inq.4, CLE 3224.T/E.1, CLE 3224.T/E.2, CLE 3224.T/E.3, CLE 3224.Math.2, CLE 3224.3.1, CLE 3224.3.2
Earth Science: CLE 3204.Inq.2, CLE 3204.Inq.3, CLE 3204.Inq.4, CLE 3204.T/E.1, CLE 3204.T/E.2, CLE 3204.T/E.3, CLE 3204.4.4
Ecology: CLE 3255.Inq.2, CLE 3255.Inq.3, CLE 3225.Inq.4, CLE 3225.T/E.1, CLE 3225.T/E.2, CLE 3225.T/E.3, CLE 3255.1.1, CLE 3255.1.4, CLE 3255.3.1, CLE 3255.3.2, CLE 3255.4.4, CLE 3255.4.5, CLE 3255.5.3, CLE 3255.5.5, CLE 3255.6.3, CLE 3255.6.4
Environmental Science: CLE 3260.Inq.2, CLE 3260.Inq.3, CLE 3260.Inq.4, CLE 3260.T/E.1, CLE 3260.T/E.2, CLE 3260.T/E.3, CLE 3260.Math.2, CLE 3260.2.2, CLE 3260.4.2, CLE 3260.4.4, CLE 3260.6.1, CLE 3260.6.3
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