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FROST SCIENCE

CUBA

JOURNEY TO THE HEART OF THE CARIBBEAN

ACTIVITY GUIDE

IN IMAX AND GIANT SCREEN THEATERS

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BRAD KREMER ERIC FREIDENBERG ANDRES LEVIN

PETER H. CHANG CHRISTOPHER DOYLE, HKSC JUSTIN HENNING

PETER ZUCCARINI ROBERT MOORING MOSE RICHARDS MYLES CONNOLLY

KELVIN BRANNON MIKE DAY DAVE DUSZYNSKI JOSHUA COLTZ DON KEMPF

NEIL NIGHTINGALE JONATHAN ROWE ANDY WOOD

VIOLET ANGELL PETER H. CHANG JOSUE LOPEZ LOZANO ROBERT MOORING PETER H. CHANG

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Introduction

Cuba

Cuba, the largest island in the Caribbean, is a vibrant nation full of diverse perspectives and traditions. Eleven million Cubans are proud of a culture that combines native Taino-Arawak, African, Chinese and European influences–all of which are easily seen and experienced in the country's food, music, dance and architecture. Cuba is one of the most established societies in Latin America: Steady migration started in the sixteenth century due to the island's strategic agricultural and military importance to the Spanish Crown. Its prominence awarded Cuba with some of the most storied artistic and architectural legacies in the Western Hemisphere. *CUBA* takes us on an exploration of Cuban dance, culture and nature.

Patricia Torres, the ballerina in the film, exemplifies the unrelenting drive and incredible talent of young Cubans chasing a career in the arts. She performs at the Teatro Nacional Cuba, a theater built in place of the grand 19th century theater Teatro Tacón. The Tacón was famed for its acoustics and elegant chandelier, built with highly sophisticated machinery for the era. Shortly after the advent of Cuba's independence from Spain on May 20, 1902, the facility was renamed Teatro Nacional.Today, it hosts the Ballet Nacional de Cuba, one of the most accomplished classical ballet companies in the world.

While the Teatro Nacional de Cuba is certainly a stunning architectural wonder, not all of Cuba's architectural treasures are on land. Due to large stretches of coastline, a tropical climate and crystalline shallow waters, picturesque Cuban coral cities also thrive under the sea.

Coral reefs are among the largest living structures in the world, harboring a vast array of life and providing food, recreation and protection against storms for human populations around the world. Much like urban and suburban human populations, these cities under the sea rely on a system of complex relationships to ensure the survival of all. Cuba hosts some of the healthiest reefs in the world. Extending from each corner of the country, like the antenna of a lobster, lie four reef chains extending at least 50 miles in length.

Throughout the film, you see how all of these different cultural, historic, environmental and artistic aspects of Cuba intertwine to tell a magnificent story of Cuba, the heart of the Caribbean.

Creating Corals
Grades K-2

Overview

Students will learn the basic anatomy of a coral polyp, including the difference between the parts that are plant, animal and rock. Using recycled and craft materials, they will assemble their own example polyp and discover the purpose of each body part.

Key Ideas and NGSS

1. The anatomy of a coral polyp and the purpose of each part. (K-LS1-1, K- ESS2-2, 1-LS1-1)
2. Encompassed by limestone rock and filled with living algae, the coral polyp is part of the animal kingdom. (K-ESS3-1, 2-PS1-3, 2-LS4-1)

Materials

(per student)

- Coffee filter
- 1/2 paper towel roll
- Rubber band
- 3 pipe cleaners, bent in half
- Reused fountain soda lid (or anything flat and thick, cardboard, small paper plate etc.)
- Glue
- Tape
- Paint or markers (students can choose colors)
- Paper towels or old newspapers to keep area clean when painting or coloring

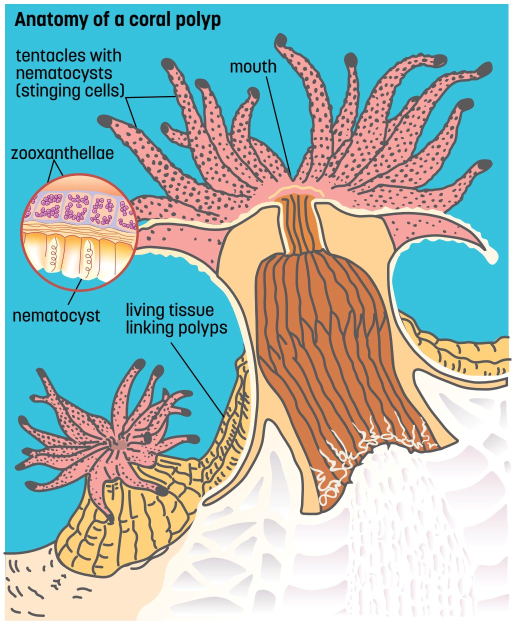
Key Vocabulary

Coral, Coral Colony, Coral Polyp, Coral Skeleton, Mutualistic Relationship, Recyclable, Tentacle, Zooxanthellae

Background information

Corals are small soft animals, known as polyps, that live in close association with each other through a common framework of calcium carbonate skeletons. Coral polyps attach themselves to a hard surface by creating a skeleton resembling hard limestone rock. At its base, this skeleton provides protection and connects them to other polyps. Much like a large apartment complex, each coral animal has its own protective walls, shared by adjacent corals that sometimes grow in massive frameworks called coral colonies. The coral polyps feed on other passing animals by capturing them with outstretched stinging cells, known as nematocysts. Nematocysts allow coral to capture prey and pull it into their mouths to be digested in their stomach. Since corals have just one opening, polyps also expel waste through their mouth. They are able to process their food and extract calcium from the surrounding seawater by hosting a symbiotic algae (zooxanthellae [zoh-uh-zan-thel-ee]) in their tissue. Zooxanthellae have a mutualistic relationship with coral polyps: this means both the polyp and algae benefit from living together. The coral provides the algae with protection and the environment it needs for photosynthesis. Even underwater, algae need light for photosynthesis, so corals are typically found where sunlight can reach them. In return, the algae produce oxygen and nutrients, and help the coral remove waste. Zooxanthellae also provide corals with much of their color; without it, most coral polyps would be clear.

This combination of coral polyp (animal), calcium carbonate skeleton (rock), and algae (plant) make corals unique in the animal kingdom because they are part animal, rock, and plant. These vast structures also harbor a wide array of other organisms such as sponges, fish, and other invertebrates (animals without backbones).



Activity Procedure (Estimated Time: 30 minutes in addition to the film)

1. Start the lesson by discussing corals with students. Ask the guiding questions below:
   a. What are corals? Are they a plant? Animal? Or Rock?
   b. Which part is plant, which part is animal, and which is rock?
2. Have students place their paper towel roll on the table. Explain this will represent the living tissue of the coral polyp.
3. Students will wrap their coffee filter around one end of the paper towel roll and secure it there with a rubber band. The bottom is now closed off by the filter. Explain that the coffee filter represents the coral skeleton.
   a. How can a coral skeleton protect a polyp?

4. Have students look into the top of the roll so they can no longer see through to the other side. Explain that this represents the polyp's mouth.
   a. How do corals eat?
   b. Where does the waste go?
5. Bend three pipe cleaners in half. Tape the creased part of the pipe cleaners to the inside of the roll so that the six ends of the pipe cleaners stick out of the open end of the roll. Explain that these pipe cleaners represent the coral polyp's tentacles.
   a. How do tentacles help corals eat?
6. Glue the bottom (side without tentacles) of the roll to the soda lid. Explain to the students the soda lid represents a hard surface onto which a coral polyp might attach itself.
   a. How do they attach themselves?
   b. How does attaching themselves to a rock or hard surface underwater change the environment?
7. Paint your polyp! Lay down newspaper or paper towels to keep the student's area clean. The color added to our coral represents zooxanthellae.
   a. What are zooxanthellae?
   b. What is a mutualistic relationship?
   c. Why do polyps need zooxanthellae?
   d. Why does zooxanthellae need polyps?
8. Have students put their polyps together while they dry. This will represent a coral colony. Together each individual polyp works together as a single organism.

Diving Deeper

Multiple coral colonies that join together become coral reefs. Coral reefs are very important ecosystems that many animals, including humans, rely on. Discuss why coral reefs are vital, and explain some of the threats facing them today. What can the students do to help coral reefs? Have the students implement eco-friendly practices in the classroom, such as recycling and turning off lights, when they leave the room.

Additional Resources

- Coral Reef Alliance - https://coral.org/coral-reefs-101/coral-reef-ecology/coral-polyps/
- National Geographic - https://www.nationalgeographic.com/animals/invertebrates/group/corals/
- What are corals? - https://www.youtube.com/watch?v=Bn2xkIJhte4

Sound Science
Grades K-2

Overview

In this activity students will make some waves… with sound! Students will learn about sound waves and the history of the carnival of Santiago de Cuba, featured in the film *CUBA*, by making their own instruments out of recyclable materials.

Key Ideas and NGSS

1. Music is very important in Cuba because it reflects Cuba's varied cultural history, combining classic European traditions with African beats and rhythms.
2. Sounds are waves of energy that we can hear. (1-PS4-1)
3. A musical instrument is any object or tool that causes vibrations and can be used to make music. (K-ESS3-3, K-PS2-1,1-PS4-4, 2-PS1-2, 2-PS1-3, K-2-ETS1-1)

Materials

(amounts will vary depending on number of students)

- Empty boxes with opening (tissues boxes, cardboard boxes, chalk boxes, etc.)
- Rubber bands
- Cylindrical cans (coffee tins, popcorn tins, etc.)
- Tape (electrical, masking, or duct tape)
- Small containers (yogurt cups, plastic bottles, soda cans, etc.)
- Small pieces (beans, beads, coins, etc.)
- Optional: pencils, construction paper, markers, tape, glue

Key Vocabulary

Carnival, Comparsas, Conga, Music, Musical Instrument, Recyclable, Sound, Vibration

Background information

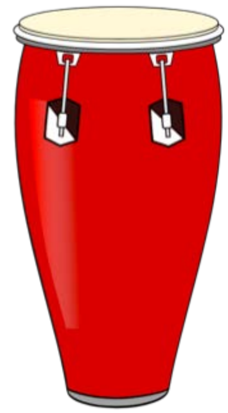


Figure 1. Conga

Cuban music is cherished around the world, and reflects the island's varied and rich cultural history. It features European traditions and African beats and rhythms and incorporates many different styles and types of music. The carnival of Santiago de Cuba is one of the most important cultural events in Santiago, Cuba's second largest city. Cuban natives and visitors from around the world come to experience the carnival, which reflects the island's varied and rich cultural history. *Comparsas* are street performances or parades comprised of neighborhood dance and musical groups that showcase Caribbean traditions and the daily life of the people of Santiago. Many participants spend the whole year preparing their routines for the event. One of the most notable instruments used in Cuba is the conga, also known as a *tumbadora*, which is a tall, narrow and low-toned drum. (Figure 1). Other common instruments seen during Carnival include various drums, rattles, and the *cornetas chinas,* or the Chinese horn.

A musical instrument is an object or tool that is used to produce sounds in a specific way to create music. Sounds are waves of energy that we can hear (Figure 2). All sounds are created by vibrations (quick back and forth motions). These vibrations travel through the air or another medium (like a solid or liquid) as waves (Figure 2). When the waves of sound reach our ears, they cause more vibrations inside our ears that allow us to hear the sound. Musical instruments work by creating different vibrations that we hear as different sounds. For example, a stringed instrument, like a guitar, makes music when its strings are plucked, causing them to vibrate. Percussion instruments, like congas and rattles, are hit, shaken, rubbed, or scraped to make sounds. When the material stretched over the top of the drum is hit, it vibrates to make sound. When those sounds are put together in certain ways, we can create music.

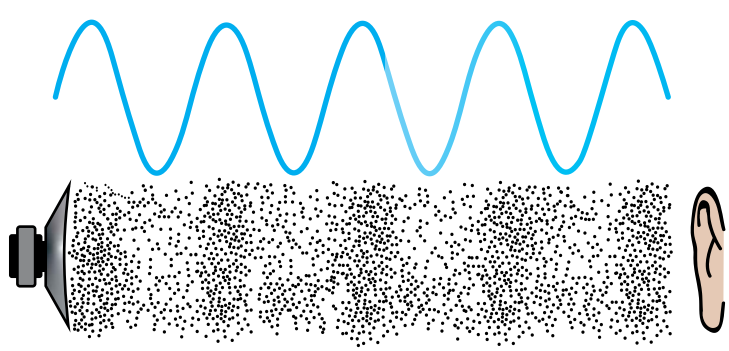


Figure 2. Visualization of a sound wave traveling through the air, vibrating air molecules, from a speaker to an ear.

Activity Procedure (Estimated Time: 45-minutes in addition to the film)

1. Introduce the activity by asking the guiding questions below:
   a. How do we hear sounds?
   b. What types of things make sounds?
   c. What are some examples of musical instruments? How do they make sounds?
      i. Stringed instruments: banjos, guitars, cellos, violins, harps, and even pianos.
      ii. Percussion instruments: maracas, tambourines, xylophone, drums, bongos, etc.
      iii. Wind instruments: flutes, recorders, clarinets, saxophones, tubas, and trumpets.

2. Explain that music is very important in Cuba, especially during the Carnival celebration in Santiago de Cuba.
   a. Discuss the different types of instruments that are common in Cuba, like the conga.

3. Explain the following concepts:
   a. Sounds are waves of energy that we can hear.
   b. Sounds waves are created by vibrations.
   c. Musical instruments work by creating vibrations.

4. Have students put their hand on their throat and then talk or sing to each other. Ask the following guided questions:
   a. Can you feel the vibrations?
   b. Do the vibrations change if you yell versus when you whisper?
   c. What about when you hum versus when you are speaking normally?

5. Next, have students rest both hands and an ear on their desk. Then have them lift one hand up and down to hit the table like a drum, while leaving the other hand on the table. Ask students the following guided questions:
   a. Can you feel the vibrations caused when you hit the table?
   b. Can you hear the vibrations through the table?

6. Explain that sound waves can travel through the air, solids (like the table), and even through water.
   a. Ask if students have been able to hear their friends or parents call their name while they were swimming under water?

7. Tell students that they will now have the chance to make their own musical instruments out of recyclable materials.

  a. Explain that recyclable materials are materials that are able to be used again. Using recyclable materials helps us protect the environment by minimizing waste that would otherwise end up in a landfill.

8. Provide students with the following instructions:

  a. Students can make one or more of the following instruments:

    i. Guitar - Stretch four to eight rubber bands of increasing widths over a box with a hole or opening in it (such as tissue box). Place a pencil under one end of the rubber bands to tighten them and change the sound. Decorate as appropriate using optional materials.

    ii. Drum – Take an empty cylindrical container (like a coffee tin) and completely cover the open top with strips of tape (electrical, masking, or duct tape; try using different types of tape to see if the sound changes). Decorate as appropriate using optional materials.

    iii. Shakers – Fill any empty, small container (like yogurt cups, plastic bottles, or aluminum cans) with small pieces that make noise when rattled (like beads, beans, marbles, or buttons). Seal the lid or opening. Decorate as appropriate using optional materials.

  b. Allow students to experiment with their musical instrument, making different types of sounds. Try causing different vibrations by plucking different strings/ hitting the drum with hands versus a pencil/moving the shakers at different speeds.

  c. Encourage students to notice the differences in the sounds, and prompt them to create music by combining different sounds

9. Wrap up activity by asking students to help clean up. Encourage students to take their instruments home or recycle the pieces.

Diving Deeper

To expand or extend this activity, ask students to create Carnival-style masks that they can they can wear while they make music with their new instruments. Students can form *comparsas*, creating music and dances in honor of the Carnival of Santiago de Cuba.

Additional Resources

- Chrome Music Lab - https://musiclab.chromeexperiments.com/Experiments
- "Musical Instruments" BrainPOPJr. Video - https://jr.brainpop.com/artsandtechnology/music/musicalinstruments/
- Simple Wave Simulator Interactive - https://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Simple-Wave-Simulator/Simple-Wave-Simulator-Interactive
- "What is Sound?" SciShow Kids Video - https://www.youtube.com/watch?v=3-xKZKxXuu0

Getting to the Core
Grades 3-5

Overview
Students will discover how scientists, like those featured in the film *CUBA*, use core samples to learn about past environmental conditions. These scientists make their own coral core sample model, showcasing each era in Cuba's history.

Key Ideas and NGSS

1. Paleoclimatology is the study of ancient climates. (3-LS4-1, 4-ESS1-1)
2. Corals form skeletons that record environmental conditions in their growth bands, similar to the growth rings in trees. Corals can record temperature, light, and nutrient conditions. (4-LS1-1, 5LS1-1)
3. Core samples can be taken from coral skeletons to analyze in a lab and determine past environmental conditions. (3-ESS2-2, 5ESS3-1)

Materials
(amounts will vary depending on number of students)

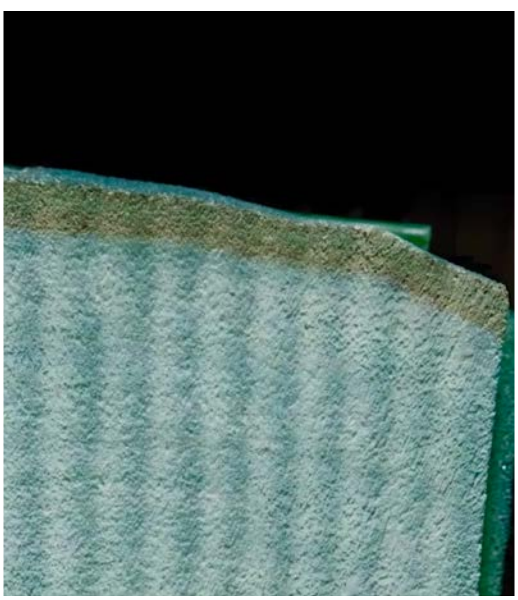
- Playdough (4 different colors, one of each color per group)
- Clear film cannisters w/caps (or other small, clear container; one per student)

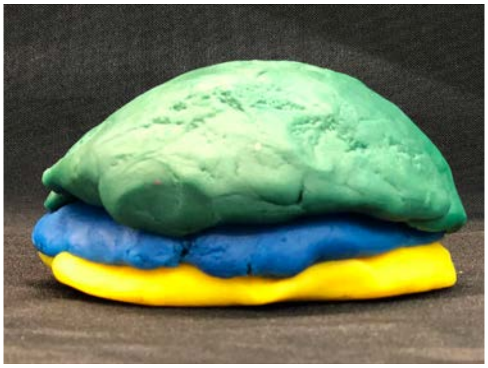
Key Vocabulary
Agriculture, Chemical Fertilizers, Climate, Coral Skeleton, Gardens of the Queen, Organic, Paleoclimatology

Background information

Paleoclimatology is the study of ancient climates, prior to the widespread availability of instrumental records. Similar to the way archeologists study fossils and other physical clues to gain insight into the prehistoric past, paleoclimatologists study several different types of environmental evidence to understand what the Earth's past climate was like and why. Coral skeletons are one such type of environmental evidence. As corals grow, they form skeletons by making calcium carbonate (limestone) from the ocean waters. The density of these calcium carbonate skeletons changes as the water temperature, light, and nutrient conditions change, giving coral skeletons different bands or growth rings that can record the seasons' climate, similar to the growth rings seen in trees. The chemicals in each band can also reflect the nutrient conditions in the ocean when the layer formed. For example, increases in nutrient run-off from land can be identified in the different bands of the coral skeletons seen in the film *CUBA*.

In order to see the information trapped in coral skeletons, scientists drill cores out of large coral heads, taking only a small sample from the larger coral colony. The holes are then filled and sealed. Eventually, the living coral tissue grows over the covered hole, allowing the coral colony to continue growing. Scientists then take x-ray images of the coral cores to better see the annual growth bands. Small samples from each growth band can also be taken to analyze chemical content. The study of paleoclimates has been useful for showing that the Earth's climate system can shift between dramatically different climate states in a matter of years or decades. Studying the climate of the past also helps scientists understand how humans have and are influencing the Earth's climate system, and even specific ecosystems, such as coral reefs.





Activity Procedure (Estimated Time: 30 minutes in addition to the film)

1. Introduce activity by asking the guiding questions below:

a. What is climate?
b. How can we learn about the climate of the past, before we had written records?

2. Explain that scientists can use environmental evidence (such as tree rings, ice, coral and sediment cores) to understand what Earth's past climate was like and why. This study of ancient climates is called paleoclimatology.

a. Coral cores taken from coral skeletons were used to understand the changing environmental conditions in Cuba and why the Gardens of the Queen reefs are so healthy.

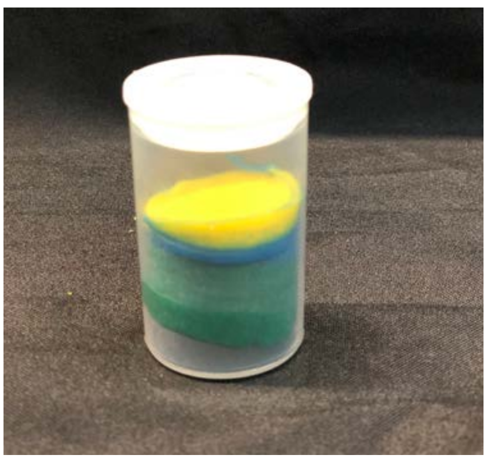
3. Explain how corals can reveal past climate conditions through their growth rings and that students will have the opportunity to recreate their own coral skeleton core out of playdough that models the changing nutrients in the Gardens of the Queen throughout Cuba's history.

4. In groups, have students work to build a model coral using three different colors of playdough to create three distinct layers. It should be roughly the size and shape of half a large grapefruit. Leave the fourth playdough color to the side. Explain how each layer represents an era in Cuba's history:

a. Bottom Layer - Before 1960, when Cuba did not use modern agricultural methods, such as chemical fertilizers.

b. Middle Layer - 1961 to 1991, when Cuba's agricultural industry used chemical fertilizers subsidized by the Soviet Union to maximize sugar production.

c. Top Layer - After 1992, when Cuba's agricultural industry had to switch to organic methods after the collapse of the Soviet Union, and toxic run-off from land into the ocean was eliminated.

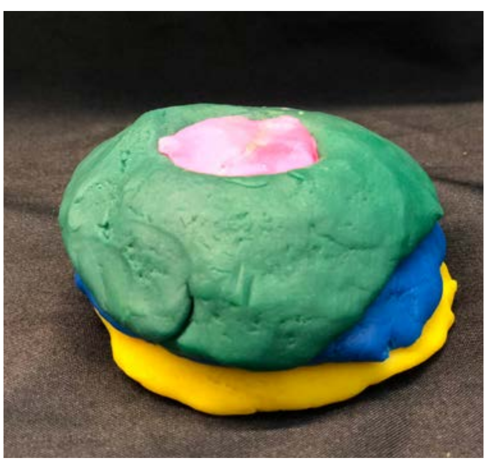


5. Once the groups have completed their playdough coral skeleton, have students take a core sample from the coral skeleton using their clear film cannisters by inserting it into the playdough as far as it will go, twisting, and then removing it. Students should be able to see each layer of the model coral in their core sample.

6. Explain how scientists use various methods to study each growth layer in the coral core to determine the past environmental and climate conditions of a particular area.

7. Have students complete their core sample methodology by filling the core sample hole with the fourth playdough color, so the surface of the coral skeleton is even and can continue to grow uninterrupted.

8. Conclude the experience by explaining how environmental evidence like coral cores helps scientists understand how humans have and are influencing the Earth's climate system.



Diving Deeper

To expand or extend this activity, freeze a balloon filled with water. Remove the balloon from the ice ball and observe the air bubbles trapped in the ball of ice before and after rinsing it with water. Explain that scientists also use ice cores as environmental evidence. In real glacial ice, these air bubbles will contain trapped air samples of the atmosphere from that point in time. Scientists use these trapped air bubbles in ice cores to analyze the composition of the atmosphere in the past.

Additional Resources

- "Coral Cores - Windows into Past Climate" Video - https://www.youtube.com/watch?v=CqhI_imLWaO
- Ice Core Activity and Videos - https://byrd.osu.edu/create-classroom-ice-cores

A Scientist's Steps for Coral Coring


Divers drilling a hole in a coral*


Coral filled & sealed*


Coral core sample taken for reserch*

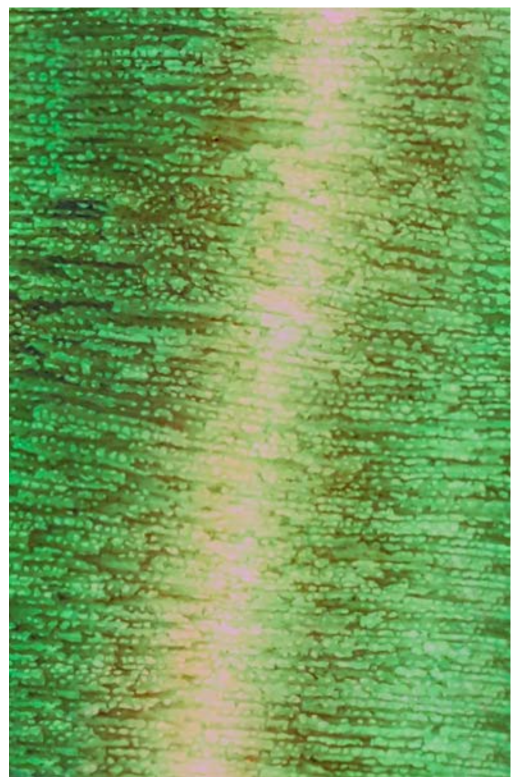

Coral sample x-ray photo

*Image credit: Fernando Bretos

Self-Made Mechanics
Grades 3-5

Overview
In the *CUBA* film, we see Cubans repairing old cars and using creative measures to fix broken parts. These self-made mechanics must use innovative measures to ensure their car continues to work. Students will use their resourcefulness to add a variety of craft materials to matchbox cars in order to make them move across a flat surface.

Key Ideas and NGSS
1. Innovative designs can be used to make a toy car move across a flat surface using a variety of forces. (3-PS2-4, 5-PS2-1)
2. Energy can be transferred from one moving object to another. (4-PS3-3, 4-PS3-4)

Materials
(amounts will vary depending on number of students)

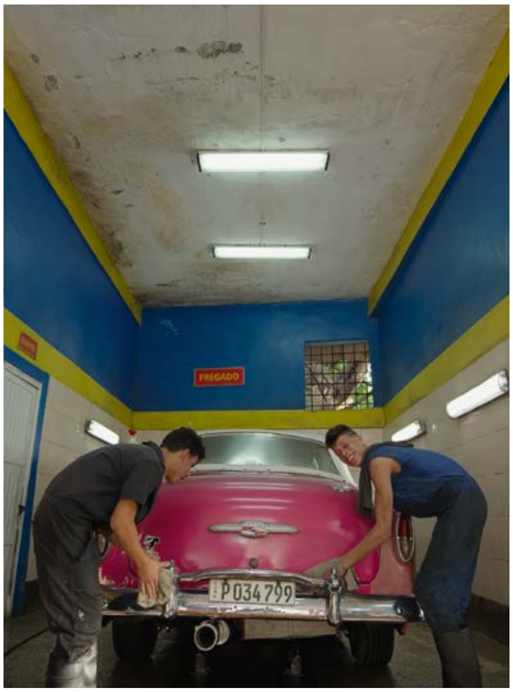
- Matchbox car (one per student or group)
- Flat surface
- A box full of a variety of materials such as: Cardboard, beads, straws, magnets, balloons, rubber bands and string (feel free to add materials)

Key Vocabulary
Constraints, Energy Transference, Force, Gravity, Innovative, Magnetic Force, Motion

Background information
American cars were imported into Cuba in the early 20th century. However, after the Cuban Revolution, the U.S. economic embargo banned the import of American cars and their parts. This forced Cubans to use innovative ways to repair automobiles and keep their cars running. Old American cars are still seen on the streets of Cuba.

In order to make something move, one must understand forces. In science, a force is the push or pull on an object with mass that causes it to change velocity. There are many different types of forces. Some, such as gravity or magnetic force, do not require contact with another object. The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center (or down towards the ground). Magnetic force occurs when two objects are either attracted or repulsed by each other based on their directional charge.

Other forces require interactions or even contact. Energy transference, for example, is defined as the exchange of one form of energy into another, or the movement of energy from one place to another. Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be exchanged between the two objects, which changes their motion - similar to when a ball is dropped on the ground and bounces back up after hitting the surface. Another example is solar panels, which allow for energy transfer from light energy into heat and electrical energy. Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light.



Activity Procedure

(Estimated Time: 30 minutes in addition to the film)

1. Have a discussion with the students about the self-made Cuban mechanics and why they needed to be innovative to fix their cars.

2. Explain to students that they are going to make their own cars move by experimenting with different forces. Their challenge is to make their car move along a flat surface without touching it, using only materials available to them and their own creativity.

3. In order to make their cars move in a forward motion, they must use different forces. Explain what a force is and discuss some possible ways they make their cars move.

a. Magnetic Force
b. Gravity
c. Energy Transference

4. Students can work on this challenge as individuals or in small groups. They may come up with different ideas to solve this challenge.

a. They should be able to compare and contrast different techniques.

b. They must follow the rules, or constraints:

i. No touching the car directly.
ii. It must stay on a flat surface (do not use a ramp).
iii. Only use materials available to them.

c. You can provide examples of ideas, including but not limited to:

i. Magnets (Magnetic Force) – Attach a magnet to a stick and another to the car. Use the stick to pull the card forward with magnetic force.

ii. Cardboard and Wind (Air Resistance Force) – Attach a piece of cardboard to top of car. Blow on the back of the cardboard to push the car in a forward motion.

iii. String & Bead (Gravity) – Attach a bead to the top of a car and pull the string through. Secure the string to one end of the table, lightly lift the other end of the string to move the car forward using gravity.

iv. Optional: Show Ted-Ed Video in Additional Resources.

5. Have the students break into small groups or work individually for 20 minutes. They can use any of the available materials to design and test their solutions to the challenge.

6. Have groups or individuals come together and show their solutions.

7. Have a discussion with the class. Which solutions worked best and why?

Diving Deeper

Mechanics need to make sure cars move, but sometimes they also have to build a car from scratch. Have students use recycled and craft materials to build their own car. How can they incorporate the techniques they learned for moving their match box cars into the design of their own car? What does the car need to work?

Additional Resources

- Newtons 3 Laws, with a bicycle Ted Ed- https://www.youtube.com/watch?v=JGO_zDWmkvk
- The Physics Classroom- https://www.mwit.ac.th/~physicslab/applet_04/physics_classroom/Class/newtlaws/u2l2b.html
- Science and Health Education Partnership - http://www.seplessons.org/node/3718

Soil Acidity
Grades 6-8

Overview

In watching the *CUBA* film, we learned that the soil in Cuba is comprised of highly fertile limestone. Students will learn about soil acidification and how calcium carbonate can be used to reduce soil acidity.

Key Ideas and NGSS

1. Limestone is made of calcium carbonate and is found in some soils, affecting the growth of plants. (MS-LS1-5, MS-LS2-1, MS-PS1-2, MS-PS1-3)
2. Soil can be too acidic for a variety of reasons, but farmers can alter the soil to create optimal growing conditions for their harvest. (MS-LS2-1, MS-LS2-4, MS-PS1-2, MS-PS1-3, MS-PS1-5)

Materials
(per group)

- 3 jars
- 3 cups soil
- 1.5 cups distilled water
- 3 mixing spoons or sticks
- 12 pH Strips
- Masking tape
- Timer
- Marker
- Vinegar
- Goggles
- 12 tums® antacid tablets or 12 teaspoons of liquid antacid
- Data recording sheets (Tables 1 & 2)
- Liquid measuring equipment (cup, 1/2 cup, teaspoon and tablespoon)

Key Vocabulary

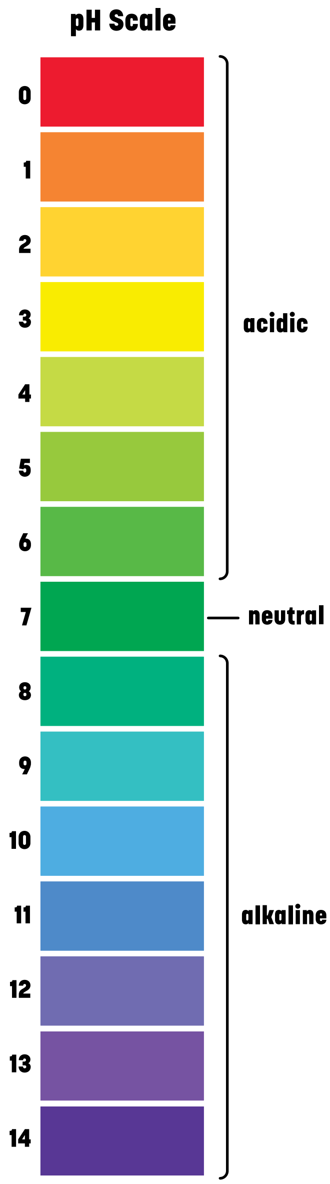
Acid, Agriculture, Alkaline, Base, Calcium Carbonate, Chemical Fertilizer, Control Variable, Limestone, Neutral, pH, Soil Acidification, Species

Background information

Limestone is mostly made up of calcium carbonate, and is a common sedimentary rock found in widespread geologic deposits, including in ocean animals such as coral and shells. Most limestone were originated from deposits found on the ocean floor, which turned into rock and uplifted into land over millions of years. Limestone has been used for many things throughout history, including building material, cement, and in agriculture.

In agriculture, limestone is used to make soil less acidic. Calcium carbonate can neutralize soil acidity because it is a base, or alkaline. There are many reasons soils can become acidic. Soil acidification is a natural process accelerated by agriculture. Soil acidifies because the concentration of hydrogen ions in the soil increases, possibly through the addition of acid in rain or soil water. However, the main cause of soil acidification is inefficient use of nitrogen. Plants take up nitrogen in the soil and when they are grown and removed rapidly, it can make the soil more acidic. The soil pH value directly affects nutrient availability. Different types of plants thrive best in different soil pH ranges. Cuba is known for a variety of crops, including tobacco, citrus, sugar and coffee, which thrive in its limestone rich soil.

Farmers can change the chemical makeup of soil by altering its pH through the addition of limestone or fertilizer. A chemical reaction occurs when the atoms that make up the original substances are regrouped into different molecules.



Activity Procedure

(Estimated Time: 45 minutes in addition to the film)

1. Cuba has highly fertile limestone soil, which is used to grow a plethora of crops, including tobacco, citrus, sugar and coffee. Discuss why Cuba has so much limestone in its soil using the prompt questions below:

a. What is limestone?
b. Where does limestone come from?
c. What is limestone used for?
d. Hypothesize why they think limestone is good for agriculture.

2. Have students put on protective glasses. They will first practice testing the pH of the substances they will be using in the activity. Before getting started, review pH using the prompt questions below.

a. Discuss the pH scale. What does it mean to have a high and low pH?
b. Water should be neutral. Discuss why water is neutral and what it means.
c. Antacid should be more alkaline. We will be using antacid Tums® as our base because it has calcium carbonate, which is the main component of limestone.
d. Vinegar should be more acidic than the other two substances.

3. Put a masking tape strip on each jar and label each one "Water," "Vinegar," and "Antacid" with a marker, and add a couple of teaspoons of each substance to the correct jar.

a. If using antacid tablets, crush three and mix with water.
b. What do the students think will happen to each substance? Have them guess the pH for each on Table 1 (on worksheet on page 18).

4. Following the directions on the pH strips, take the pH of each substance to get a preliminary measurement and record it on Table 1.

5. Dispose of substances in each jar, wash thoroughly and remove label.

6. Put a masking tape strip on each jar and label each one "Soil Sample 1," "Soil Sample 2," and "Soil Sample 3"

Activity Procedure (cont.)

7. Pour a cup of soil and about a 1/2 cup of water into each of the three jars. Mix well. The soil should be goopy, like dirt pudding.

8. Following the directions on the pH strips, take the pH of each jar of soil mixture to get a base measurement and record it on Table 2 (on worksheet on page 18).

9. Now students will make the soil more acidic. Discuss soil **acidification** using these prompt questions:

a. What is soil acidification?
b. How does agriculture influence soil acidification?
c. What is the purpose of fertilizer and can that affect soil acidification?
d. What happens to plants if the soil is too acidic?
e. Does this vary among plant species?

10. Students will mimic soil acidification by adding vinegar to two of the sample jars using the pipette or eye dropper. Vinegar is an acid.

a. Take jar marked "Soil Sample 2" and add one teaspoon of vinegar. Mix well.
b. Take jar marked "Soil Sample 3" and add 3 tablespoons of vinegar. Mix well.
c. Jar marked "Soil Sample 1" will be the control variable. Define control variable for students and discuss how important it is for experiments.

11. Set timer for 5 minutes. Have students hypothesize the new pH of the soil will be based on what they know about vinegar's pH and record on Table 2.

12. After timer goes off, take pH of all three jars and record the pH on Table 2.

13. Next, discuss the opposite end of the pH spectrum, alkaline soil. Use the prompt questions below.

a. What is basic/alkaline soil?
b. What do you think will happen when the base is added to the soil?
c. Have students record their hypothesized new results after adding antacid to the soil on Table 2.

14. Add three crushed antacid tablets (or three teaspoons of liquid antacid) to each of the three jars. Mix well.

15. Set timer for five minutes. After timer goes off, record the pH on Table 2.

16. Have a discussion with students about what happened when the students added calcium carbonate to the acidic soil and how this relates to agriculture in Cuba. You can use the question prompts below.

a. How can farmers use the knowledge of bases and acids to help them farm?
b. If limestone is made of calcium carbonate, how can farmers use it in farming?
c. What crops thrive in Cuba?

Diving Deeper

What plants thrive in soils with different pH levels? Create gardens using soils with different pH and grow a variety of herbs and plants in the classroom. As the plants grow, observe which ones thrive under which conditions.

Additional Resources

- Limestone in Agriculture- https://www.cropnutrition.com/calcium-carbonate
- Soil Quality - http://soilquality.org.au/factsheets/soil-acidity
- Why do we add lime? YouTube - https://www.youtube.com/watch?v=p9N7H6he6CM

Soil Acidity Worksheet

Name(s):____ Date:___________________

In agriculture, soil has to be a perfect acidity in order for plants to grow. Soil can be too acidic or basic for a variety of reasons. Limestone is made of calcium carbonate and is found in some soils, which can change the acidity of soil and growth of plants. Sometimes, farmers alter the soil to create optimal growing conditions for their harvest using more acidic or basic sources.

Use Table 1 to estimate pH of three different substances. First, estimate and record what you believe the pH will be.
Next, follow the directions on your pH strips to determine the actual pH and record it.

TABLE 1

ACID, BASE & NEUTRAL		
	Estimated pH	**Actual pH**
Water		
Antacid		
Vinegar		

Were the results what you expected? Why or why not? ____

____

____

____

Use Table 2 to record the pH in each soil sample after altering it with acidic and basic substances. First, estimate and record what you believe the pH will be. Next, follow the directions on your pH strips to determine the actual pH and record it.

TABLE 2

SOIL SAMPLING DATA RECORDING SHEET						
	Original pH	**Vinegar added**	**Estimate pH w/ vinegar**	**pH w/ vinegar**	**Estimate pH w/antacid**	**pH w/ antacid**
Soil sample #1		0				
Soil sample #2		1 teaspoon				
Soil sample #3		3 tablespoons				

Were the results what you expected? Why or why not? ____

____

____

____

Physics of Dance
Grades 6-8

Overview

Students will discover the forces involved in multiple *pirouettes*, or turns, commonly performed in ballet and as seen in the film *CUBA* by experimenting with DIY spinning tops and their own bodies.

Key Ideas and NGSS

1. Physics can be used to explain how ballet dancers are able to perform impressive dance moves. (MS-PS2-2)
2. Ballet dancers are able to overcome the forces of gravity and friction to continually spin around by storing momentum through specific body movements. (MS-PS2-1, MS-PS2-2, MS-PS2-4)
3. Ballet dancers can spin faster and faster by distributing their mass closer to the axis of rotation. (MS-PS2-1, MS-PS2-2)

Materials

(amounts will vary depending on number of students)

- Cardboard (medium piece per student or group)
- Marker (1 per student or group)
- Scissor (1 per student or group)
- Pencil (or thumbtack/pushpin, 2 per student or group)
- Rubber bands (4 per student or group)
- Pennies (12 per student or group)
- Tape (1 roll per student or group)
- Circular object to trace (1 per student or group)

Key Vocabulary

Angular Momentum, Angular Velocity, Axis of Rotation, Friction, Gravity, Mass, Physics, Rotational Inertia, Torque

How the Angular Momentum (L) stays the same throughout multiple turns:

L=wI

L - angular momentum

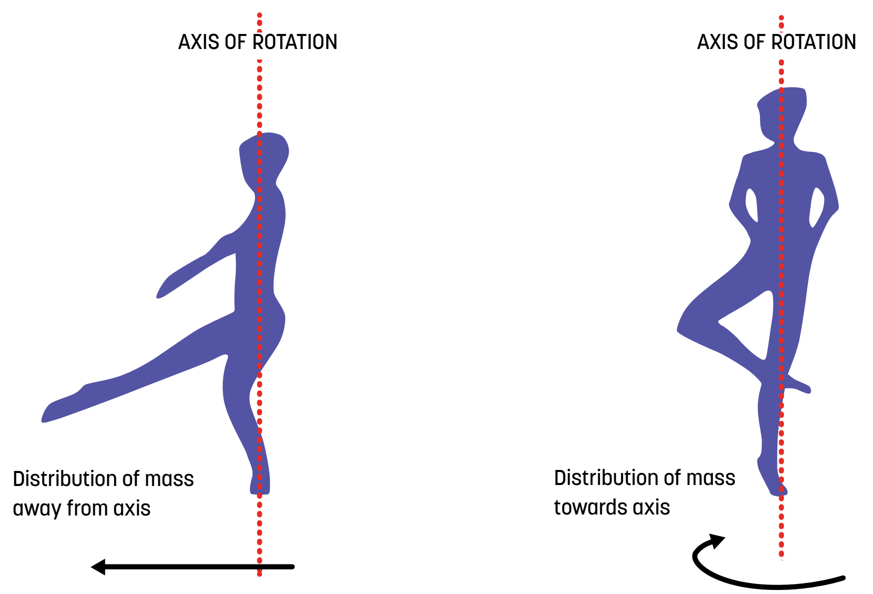
w - angular velocity

I - rotational inertia

Background information

The movements of a ballet dancer follow the laws of physics–even the moves that seem to defy them. The *fouetté*, a series of pirouettes or turns on one pointed foot, makes the dancer appear as if they are a never-ending spinning top, and can be explained through the principles of physics. The forces of gravity and friction are constantly influencing a dancer, keeping them on the ground and slowing them down, but these forces can be overcome by the use of other forces, such as torque and momentum. Through the use of specific body movements, the dancer is able to continually generate torque and conserve momentum throughout multiple turns.

To perform a *fouetté* [fwete], a dancer initially pushes and twists off the ground with their foot to generate the torque needed to spin around on the point of their foot. Each time the dancer turns around again to face the audience, the whole foot briefly touches the ground again in order to push off and generate more torque. Additionally, by continually swinging the other leg in and out throughout the spin, as well as pulling in the arms, the dancer is able to conserve momentum, allowing them to spin around many times in a row without being slowed down by gravity and friction. By pulling their arms and legs in towards their axis of rotation, they are altering the distribution of their mass, causing them to increase the speed of the turn, decrease resistance to the rotational motion, and maintain momentum. This is represented by an equation: angular momentum is equal to the angular velocity times the rotational inertia (L = wI). For momentum (L) to stay the same, the speed (w, or angular velocity) increases while the resistance to rotational motion (I, or rotational inertia) decreases as the mass is brought closer to the access of rotation.



More resistance (Rotational Inertia, **I** increases)
Slower turning speed (Angular Velocity, **w** decreases)

Less resistance (Rotational Inertia, **I** decreases)
Slower turning speed (Angular Velocity, **w** increases)

Activity Procedure

(Estimated Time: 45 minutes in addition to the film)

1. Explain that physics can be used to understand and explain how ballet dancers are able to perform dance moves that seem impossible, like the *fouetté*.

2. Ask students to brainstorm which forces might be driving on a dancer as they complete their moves, and how they might be able to overcome them.

3. Explain how ballet dancers are able to overcome the forces of gravity and friction to continually spin around by storing momentum through specific body movements. Remind students they will understand how these forces work through their DIY experiments, or even by using their own bodies.

4. Instruct students to complete the following:

a. Draw two circles that are the same size on a piece of cardboard by using a circular object like a bowl or lid. Cut them out.

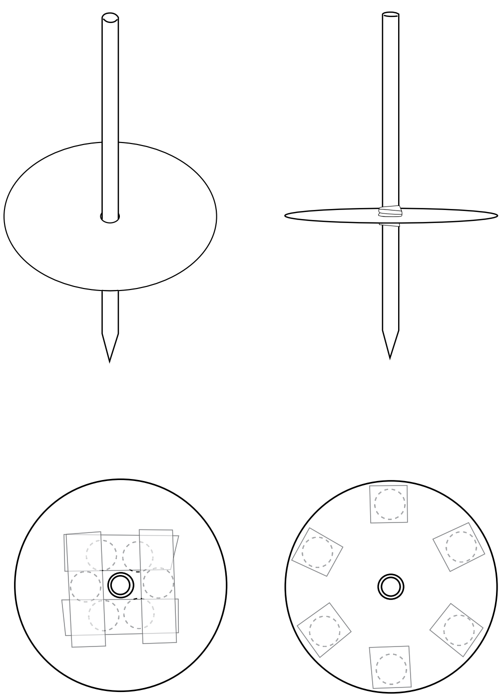
b. Poke a pencil (or thumbtack/pushpin) into the exact middle of each circle. This is the axis of rotation. Wrap rubber bands around the pencil on either side of the cardboard to keep it firmly in place.

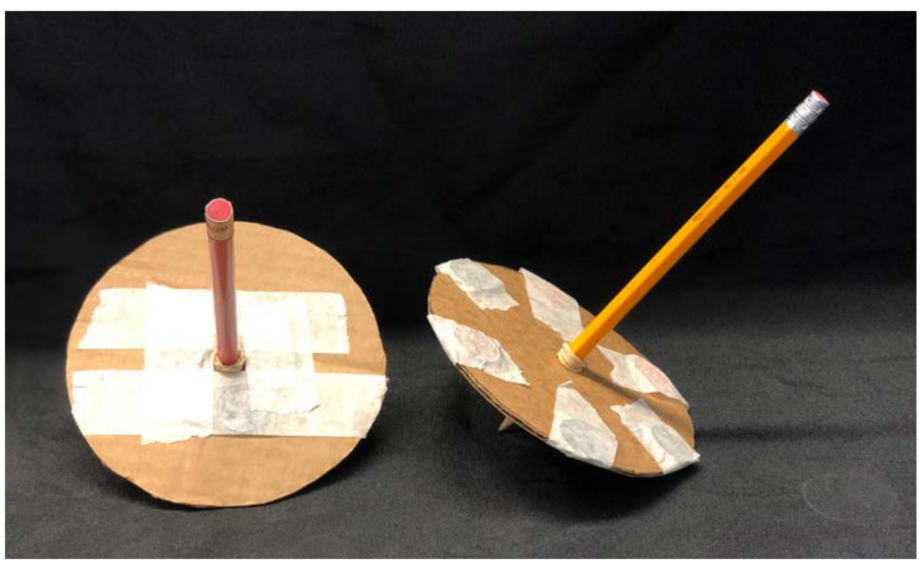
c. On the top surface of one cardboard circle, attach six pennies to the outer edge of the circle using tape (students can use less pennies depending on size of circle).

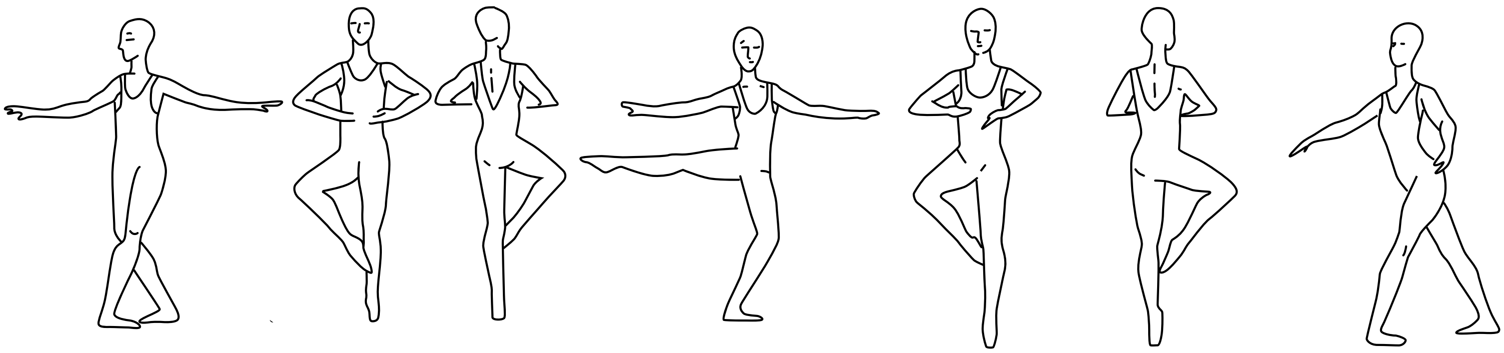
d. On the top surface of the other cardboard circle, attach six pennies as close to the pencil as possible using tape (students can use less pennies depending on the size of the circle, as long as it is the same number as on the first cardboard circle).

e. Spin each top by creating torque with your fingers.

f. Observe and discuss the differences between the two, focusing on the rotational inertia and angular velocity.







5. Next, instruct students to complete the following:

a. Stand up and try spinning in a circle on one foot, while wearing shoes and again wearing socks. Is there a difference? Why?

b. Try spinning around multiple times on one foot. Does it work?

c. Try spinning around multiple times on one foot while moving your other leg in and out during the turn, like the ballet dancers. Did it help?

d. Try spinning around multiple times while moving your leg in and out during the turn, and also pulling in your arms near your body when your leg is bent, like a ballet dancer. Did it help? Did you move faster when your legs and arms were pulled toward the axis of rotation?

6. Facilitate a discussion with students using the guided questions below:

a. How do the dancing movements we did relate to the spinning top experiment?

b. What happens when we distribute mass towards the axis of rotation?

c. How does a dancer conserve momentum when spinning around many times in a row?

d. Optional: Show Ted-Ed Video in Additional Resources.

7. Conclude activity by summarizing how dancers are able to overcome gravity and friction through specific body movements that conserve momentum. Explain how this ability can be explained through physics principles.

Diving Deeper

To extend or expand this activity, show students that spinning movements aren't the only dance moves that can be explained by physics. Instead, explore how horizontal jumps or leaps follow a parabolic trajectory or curved path. Experiment by tossing a soft ball back and forth, following the shape of the path of the ball - a parabola. Discuss the path of projectiles and the relationship between free-flying objects in motion and gravity. The vertical velocity of a projectile approaches zero at the top of the projectile path, and then accelerates once it begins to descend.

Additional Resources

- Pictures of *CUBA* documentary at 37 minutes and 16 seconds during the fouetté dance move.
- Ted-Ed Video - "The physics of the "hardest move" in ballet" - Arleen Sugano - https://ed.ted.com/lessons/the-physics-of-the-hardest-move-in-ballet-arleen-sugano#watch

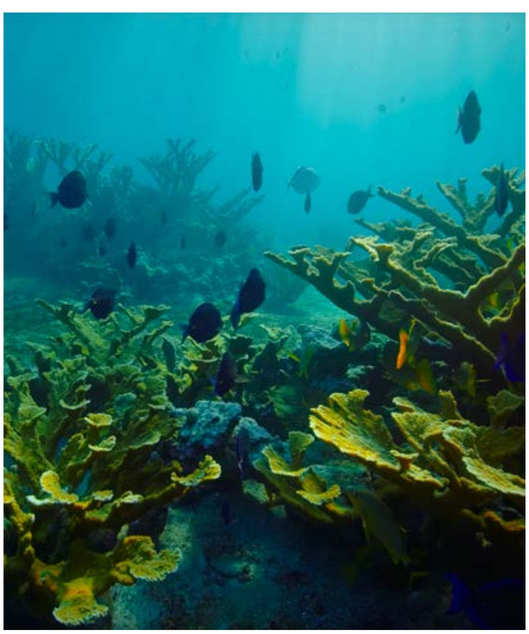
Designing a Marine Protected Area
Grades 9-12

Overview
Students will be representing opposing stakeholders and must work together to develop management strategies, including designing marine protected areas, reserves and no-take zones for Cuba's surrounding waters.

Key Ideas and NGSS
1. Numerous stakeholders and opposing opinions are involved and need to be incorporated when developing management strategies for multi-use areas with various resources. (HS-LS2-2, HS-ETS1-1, HS-ETS1-3)
2. The ocean is experiencing increasing anthropogenic threats, many of which resource managers try to mitigate through management designs and marine protected areas. (HS-LS2-7, HS-ESS3-3)

Materials
(per group)
- Stakeholder cards
- Map of Cuba and Gardens of the Queen (Figure 3.)
- Pen/pencil
- Optional: poster or Powerpoint

Key Vocabulary
Anthropogenic, Embargo, Gardens of the Queen, Marine Protected Area, Marine Reserve, No-Take Zone, Spawn, Spillover Effect



Background information
Over 20 percent of Cuba's territory is a dedicated network of more than 250 natural reserves on both land and sea. Cuban authorities have set these reserves aside for the long-term health of the island and to provide benefits for the future of Cuban people. One of these protected areas is the Gardens of the Queen (*Jardines de la Reina*). The Gardens of the Queen is a national park located about 60 miles off the southeast coast of Cuba. It is an 840-square mile archipelago named by Christopher Columbus to honor the Queen of Spain, Isabella I of Castile. It was established as a marine reserve in 1996, and a national park in 2010. It is Cuba's first marine park, and the largest no-take marine reserve in the Caribbean.

With commercial fishing and other activities restricted, the park and surrounding area provides a baseline for assessing the health of the ocean in an area relatively untouched by humans due to its long history of protection. Its connectivity between marine ecosystems, such as mangroves, sea grasses, and coral reefs, provides a home to healthy populations of sharks and other important fish, such as grouper and parrotfish, and recovering endangered species, such as elkhorn coral and hawksbill sea turtles. The park's protection has international importance because it provides comparisons for no-take zones to areas where takes are allowed, and demonstrates connectivity between marine ecosystems. Due to its thriving marine life, the Gardens of the Queen is able to promote ecotourism through scuba diving, fly fishing and bird watching.

Not all areas of the ocean are as protected as the Gardens of the Queen. Many marine habitats face increasing anthropogenic threats to their existence. Around the world, marine habitats are dying due to a variety and combination of reasons, including overfishing, destructive fishing habits, coastal development, rising ocean temperatures, changes in marine and atmospheric chemistry, and pollution. All of these issues impact the biodiversity of habitats, and are negatively impacting the long-term sustainability of marine ecosystems worldwide.

Scientists and conservationists are looking for solutions, like the Marine Protected Area (MPA) seen at the Gardens of the Queen.

MPAs are marine managed areas that contribute to the protection of natural resources and can include a variety of protections. Some are marine reserves with no-take zones, where areas of ocean are protected from extractive and destructive activities, such as fishing. Some MPAs with fisheries have different restrictions, such as gear type, species catch allowance, size allowance and access to different areas. MPAs are managed differently as well, where some may be permitted strictly by country, state, or county; others may be managed directly by the community. For MPAs to be effective, they need to have strong management policies, usually using the ecosystem-based management approach since that aims to protect the entire ecosystem as a whole. Managers must additionally look at all aspects of the services the ecosystem provides to humans, such as food and protection. There are many proven benefits to creating MPAs, including an increase in the diversity of species, number of animals, size, and reproductive potential in key fisheries species. These results have been seen inside the MPAs, as well as in the surrounding areas as marine species move into and out of protected areas.

Activity Procedure

(Estimated Time: 90 minutes in addition to the film)

1. Discuss Gardens of the Queen with students.

   a. What are the historical and current management policies there?
   b. Which important environmental aspects and resources can be found there?

2. Students will work together to redesign their own management policies on the waters in the Gardens of the Queen. They must redefine the area and discuss how they will fund management practices. They need to decide if the waters should be a Marine Protected Area, and if so, is it a full no-take zone or marine reserve with varying take limits?

   a. Break students up into groups of six and assign each individual student a stakeholder representative card.

   b. They must represent that character, their points of view and desires when determining the outcome of the new management policies for Gardens of the Queen.

3. They will have 45 minutes to design their new MPA. Using the map, they should draw out different zones in the MPA (or lack thereof). They must address the following questions:

   a. What are the known anthropogenic threats in the area?
   b. What are known resources in this area?
   c. What are the boundaries for each type of zone created?
   d. What can these areas be used for? Where? When?

      i. Can the area be used for fishing?
      ii. Can the area be used for research?
      iii. Can the area be used for recreation?

   e. Who will manage the area?

      i. Where will funds come from?
      ii. Will permits be required?
      iii. How will rules be enforced?
      iv. What are consequences for breaking the rules?

   f. How does each stakeholder feel about the final ruling?

4. Groups should present to the rest of the class (either with a poster, Powerpoint presentation, or just a discussion) on what their new management practices will be, answering all of the above questions and:

   a. What was the easiest part about coming to a conclusion?
   b. What was the most difficult part about coming to a conclusion?

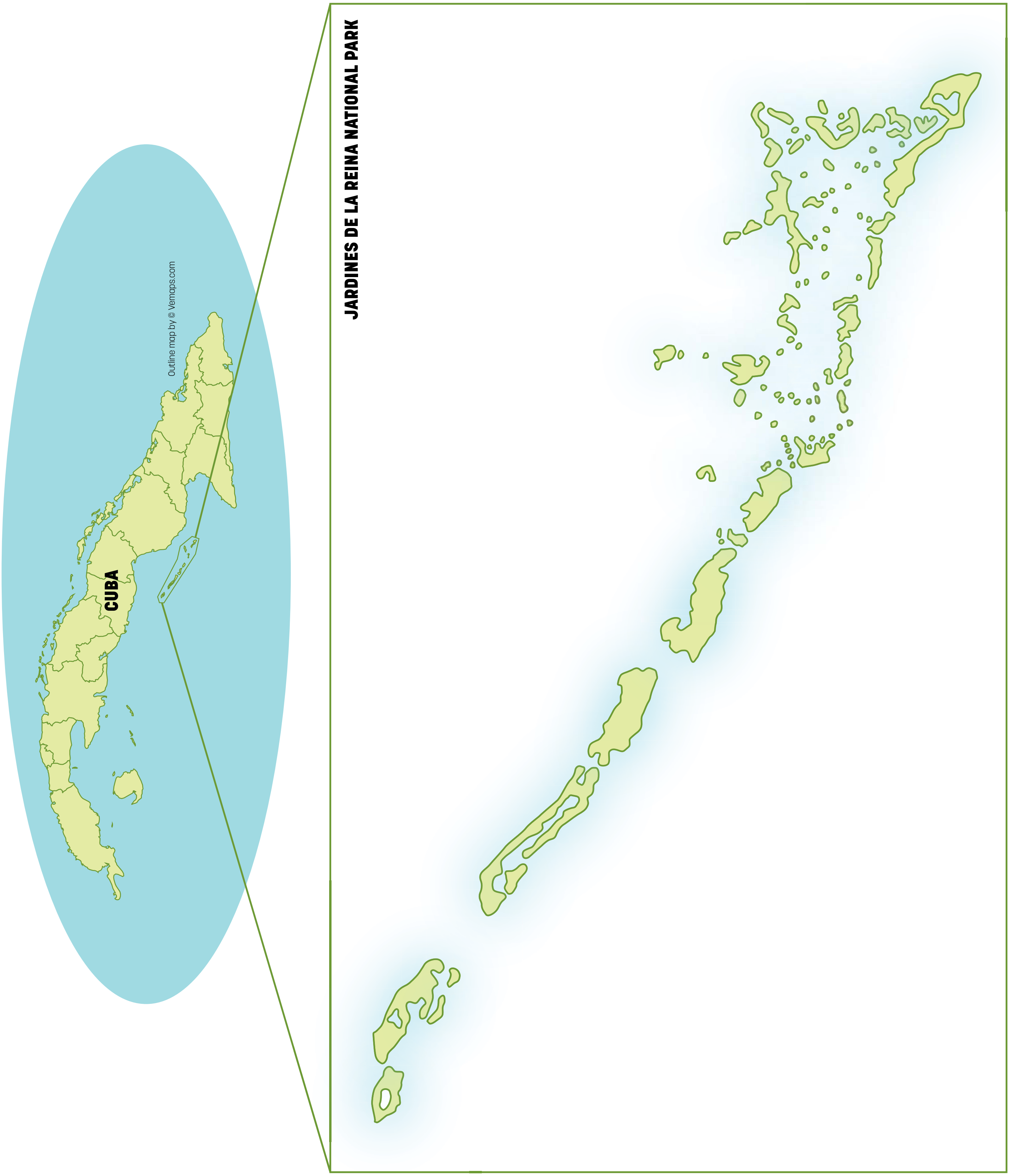
Diving Deeper

Host a debate in your classroom for and against no-take marine protected areas. Have students research scientific articles on this topic and cite their sources. Use the stakeholder cards as examples of pro and con arguments.

Additional Resources

- Marine Protected Areas in Cuba - https://www.edf.org/oceans/marine-protected-areas-cuba
- National Geographic, Stakeholder MPA Debate Activity – https://www.nationalgeographic.org/activity/marine-protected-area-stakeholder-debate/
- Reef Resilience Network, Designing an MPA- http://www.reefresilience.org/coral-reefs/resilient-mpa-design/
- Ted Ed Conserving our spectacular, vulnerable coral reefs- https://www.youtube.com/watch?v=TPmlD6demPk

Map of Cuba


Outline map by © Vemaps.com
CUBA
JARDINES DE LA REINA NATIONAL PARK

Stakeholder Role Descriptions

Each group member will receive a card and description of the stakeholder they are representing. They must read and understand their side of the argument, and develop their own arguments based on what they want to get out of a marine protected area.

- Are you okay with some restrictions, only want no-take, or don't want any restrictions?
- What are some arguments that other stakeholders could have against your opinion?

Using these cards, students will work together to design new management strategies for the Gardens of the Queen.

- What areas are no take, partially protected, or not protected at all?
- Can you all come to an agreement that works for everyone?

Commercial Fisherman Representative	**Environmentalist Representative**
Government Representative	**Research Representative**
Tourism Company Representative	**Fishery Scientist Representative**

Commercial Fisherman Representative	My livelihood is catching and selling fish. I am part of an industry that produces food for Cuban communities, while generating income for the island by exporting fish that I help catch. I am one of over 32,000 people employed by the fishing industry. Since fishing is so important to my household and this country, I need access to all of the waters and do not see any reason to have MPA restrictions where commercial fishing could be taking place. This way of life has sustained my family for countless generations. I am concerned that with more regulations, I will not be able to provide for my family, and my children will not be able to take over the business when they grow older. There should be no restrictions for marine protected areas.

Opposing Question:
What happens when there are not enough fish left to sustain your fishing business or family?

Government Representative	Cuba has a long legacy of fishing. Our current marine reserves are a wonderful example of how local government can solve its own problems and provide and opportunities for a resilient and diversified fishing industry. But is it enough? With the rate of overfishing globally, I am concerned we need more regulations and increased no-take zone boundaries in order to protect important commercial fish in our waters. There is evidence that spillover effects from no-take zones can increase the numbers of large fish outside of the MPA boundaries and that previously overfished areas can recover. The fish are born, grow and reproduce there, then grow to benefit all of us. This is the result of restricting access to the waters either limiting or prohibiting fishing. Anyone wanting to use the area for a variety of reasons will need to apply for a permit. Additionally, the more management policies we create, the more management jobs there will be, so those concerned about employment rates do not need to worry. There should be more strict restrictions for marine protected areas.

Opposing Question:
How will these new jobs be funded?

Tourism Company Representative	The Cuban tourism industry is concerned about how more regulations will affect tourism operations and Cuba's economy. Many of my friends and family rely on income from tourists coming to coastal communities for recreational activities, such as fishing and diving in the Gardens of the Queen. If there are more restrictions on using this area, how will these companies continue to function? How will hotels and restaurants thrive without receiving fresh fish from fishermen? Generations before me helped build these small coastal communities, and rely on the ocean for income. I recognize the importance of keeping these waters clean, but can we do that without no-take areas? I recommend introducing more management of the areas, including higher fines for pollution, damage or overfishing, but not no-take zones.

Opposing Question:
Who will oversee activities in the area and implement these fines?
How will the tourism industry survive if the beautiful water resources are not healthy?

Environmentalist Representative	People do not respect the ocean. Every day tons of trash washes up on shore and no one takes ownership. We need to protect the environment and our ocean because without it, our resources will cease to exist. We need places where humans can go to enjoy nature, but not take from or destroy it. Not only that, we need to pay attention to the species that use the area. The Gardens of the Queen is used by endangered and threatened species, such as American crocodiles, elkhorn coral, and hawksbill sea turtles. You can find critically important coral, mangrove, and seagrass habitats that need to be protected for the future of our oceans, including for fishing industries. I believe the Gardens of the Queen should be set aside for conservation, volunteers, restoration, and eco-tourism. These activities would create jobs and protect the environment at the same time. Cuba should have more no-take zones that can only be used for recreation.

Opposing Question:
What about business and families that rely on the fish in this area for food?

Fishery Scientist Representative	Although there have been many studies that support no-take zones, my research has proven there are other techniques to reduce the consequences of overfishing. My colleagues and I tagged and studied fish moving into and out of a no-fishing zone across the U.S., Gulf of Mexico and Caribbean. We have found more individuals may move into the protected habitats than move out, refuting the concept of spillover. With more in-depth research and regulations on specific areas or species, we can cater management to individual needs. There are better management options available to restore and sustain the fishing industry. There is no reason to go to the extreme of prohibiting all fishing or activities in the Gardens of the Queen.

Opposing Question:
Who will create, implement, and enforce all of these separate management procedures?

Research Representative	After the collapse of Soviet subsidies in 1991, Cuba ceased the use of industrial fertilizers and instead practiced organic agriculture. This history is very unique because many ecosystems, here are still pristine, including the Gardens of the Queen. As researchers, it is our duty to be able to observe this natural phenomenon. This unspoiled area can be a useful case study for resource management tactics in other areas. Many studies can be conducted in these ecosystems including animal behavior, conservation, climate, biomedical and fisheries. No-take zones are good for keeping this area pristine, however we need to be able to continue to conduct research to counter the threats facing the world like human diseases, overfishing, and climate change. I encourage no-take zones in the Gardens of the Queen, but with exceptions for managers to allow scientists to use the area in order to take samples, observe, and study.

Opposing Question:
What are the limits on who can claim they are entering for science and who will give out the permits for research?
What about tourism and fishing industries?

Art and Architecture
Grades 9-12

Overview
Using the Catedral de la Habana as inspiration, students will implement elements of the engineering design process to create a floor plan and build a structure using recyclable materials, drawing parallels to the coral blocks, an important natural resource used to construct the cathedral and other historic buildings seen in the film *CUBA.*

Key Ideas and NGSS
1. Before creating a structure, engineers must first come up with a plan for the design, which is often illustrated in a floor plan. (HS-ETS1-2)
2. Engineers must consider the environmental impacts of the materials used in construction. (HS-ETS1-1, HS-ESTS1-3)
3. Technologies such as 3D modeling can be used for the digital preservation of historically and culturally important structures. (HS-ETS1-4)

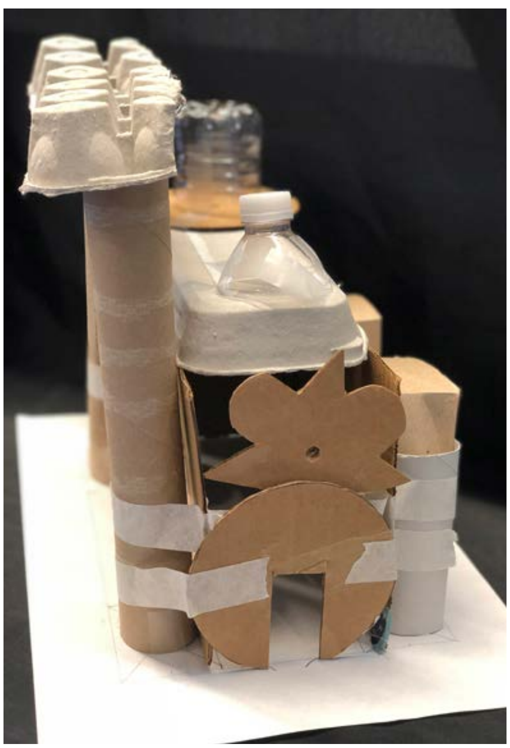
Materials
- Paper 11 in x 17 in (1 per group)
- Pencil (1 per group)
- Ruler (1 per group)
- Recyclable materials (cardboard, paper, water bottles, popsicle sticks, etc.)
- Tape and/or glue (1 per group)
- Optional: smart phone (1 per group)

Key Vocabulary
3D modeling, Baroque, Catedral de la Habana, Coral, Floor Plan, Neoclassical, Sustainable

Background information
The *Catedral de la Habana* (Havana Cathedral), also known as the *Catedral de San Cristobal*, is one of eleven Catholic cathedrals in Cuba located in the *Plaza de la Catedral.* The church serves as the seat of the Roman Catholic Archdiocese of San Cristobal de la Habana. Construction began in 1748 and was completed in 1777. The 30-by-49-meter rectangular church features Baroque and Neoclassical architectural elements. Baroque architecture often includes curving forms such as "wavy" walls and oval shapes, large open spaces, unproportionately large features twisting columns, clusters of dramatic elements, and lots of rich detail, like projecting wall elements and painted ceilings. Neoclassical architecture often includes large-scale structures, dramatic use of columns (sometimes multiplied or stacked to create an impression of height), enlarged domes, and blank walls. Before architects and engineers can build a structure such as the *Catedral de la Habana*, they need to plan out their designs. This is often done through the use of a floor plan, which showcases the size and arrangement of rooms or buildings and placement of architectural features.

Architects and engineers must consider the materials they plan to use when designing and building structures, as well as the impacts of those materials. Many of the buildings in Cuba were built using coral blocks mined from the sea. Coral continues to be a common building material today. However, mining coral can have many negative environmental impacts, such as a loss in biodiversity by damaging slow-growing coral reef ecosystems. This, in turn, exposes the coastal shore to increased storm surges by removing natural barriers, and even results in economic losses due to the importance of healthy coral reefs for food and tourism. With coral reefs already under threat due to a variety of other factors, it is important to choose alternative sustainable materials when building structures.

Technology is often used in the design and preservation of structures. The use of 3D modeling in construction speeds up the design process, but also enables architects to be more creative and experimental in their work by testing out different ideas. It also allows them to identify potential design problems before they become actual issues. Additionally, this technology provides an opportunity to preserve historically and culturally important structures that may be falling into disrepair or subject to damage from natural disasters. The precise documentation of these important structures is essential for their continued protection and scientific studies.



Activity Procedure

(Estimated Time: 1 hour in addition to the film)

1. Ask the guided questions below to introduce the activity:

a. What are the considerations engineers must take into account when designing and building a structure?
b. Coral blocks were and continue to be used for construction purposes. What are the environmental impacts of using coral blocks for construction? What are other possible alternatives?
c. How do engineers plan out their design for a structure?

2. Show images of the *Catedral de la Habana* from this guide or the 360° Google Street View Photo Spheres at the link below, explaining its baroque and Neoclassical architectural style and use of coral blocks as building material.

3. Explain that students are going to design and build their own structure, utilizing the same architectural elements as the Catedral out of recyclable materials, highlighting the use of sustainable materials versus limited natural resources.

4. Provide students with the floor plan example of the *Catedral de la Habana*.

5. Instruct students to complete the following:

a. Plan out the design for your structure by creating your own unique floor plan, using the example provided for inspiration.
b. Build your structure using the provided recyclable materials based on your floor plan.
c. Return to the design phase as needed to create a stable structure that meets aesthetic requirements, meaning it features Baroque and Neoclassical elements.

6. When students are done building, explain that 300 years has gone by and their structure is beginning to collapse. Ask students to brainstorm ways that the structure itself and/or it's design can be preserved, leading students to the use of technologies such as 3D modeling to digitally preserve the structure of the building.

7. Optional: Show examples of cultural heritage and historical 3D models found at the link in the Additional Resources.

Diving Deeper

To extend or expand this activity, use the free iPhone application Trnio, downloaded on a smart phone, to create a 3D model. Follow the prompts on the screen to create a 3D model of the structure created by students, highlighting how 3D technologies can be used to digitally preserve structures.

Additional Resources

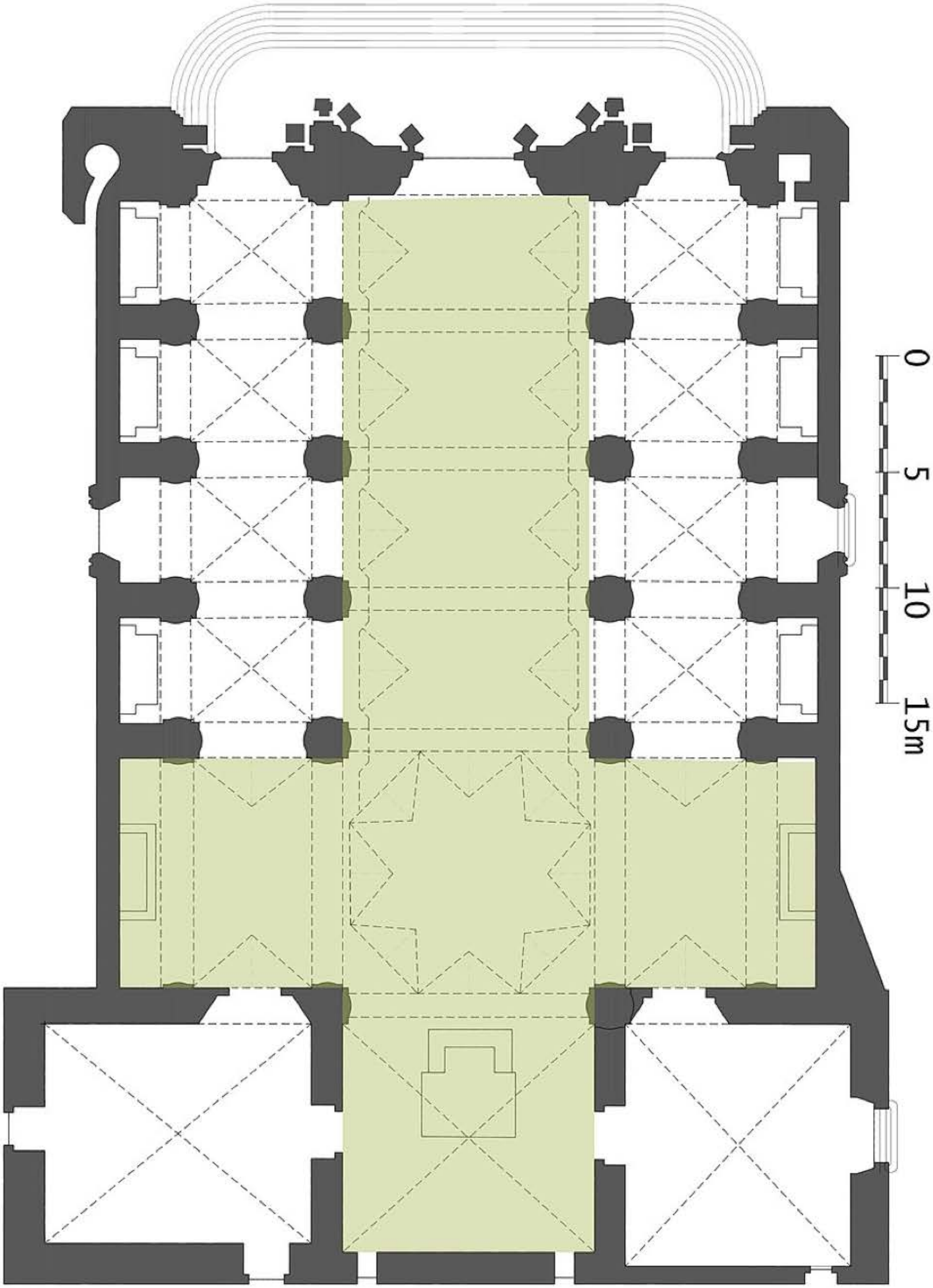
- Catedral 360° (click to view Street View and select Photo Spheres to tour) - https://bit.ly/2EsTVJa
- 3D Model Examples - https://sketchfab.com/models/categories/cultural-heritage-history
- Trnio App - http://www.trnio.com/

Havana Cathedral

Havana Cathedral

Images by: Emmanuel Huybrechts

Sample floorplan



Citizen Science: BioBlitz in Your Backyard
Grades K-12

Overview
Students will learn how they can contribute to real scientific data collection through citizen science. They will use the iNaturalist application to survey biodiversity in their area and discuss Cuba's biodiversity.

Key Ideas and NGSS
1. Citizen science enables everyone to contribute and be involved in science, often through data collection and analysis. (5-ESS3-1, MS-LS4-4, HS-LS2-2)
2. Data can be collected on flora and fauna in varying environments to determine patterns in locations, behaviors and adaptations. (K-LS1-1, 1-LS3-1, 1-LS1-2, 2-LS4-1, 3-LS1-1, 4-ESS1-1, MS-LS2-2, MS-LS2-4, HS-LS2-6, HS-LS2-8)
3. Greater biodiversity in an ecosystem ensures long term sustainability for all life forms (3-LS4-4, MS-LS2-5, HS-LS2-7).

Materials
Smartphone or tablet device with iNaturalist application installed

Key Vocabulary
BioBlitz, Citizen Science, Biodiversity, Flora, Fauna, Organisms, Data, Database, Observation, Pattern, Population, Environment

Background information
Citizen Science is the involvement of the general public in scientific research through the collection and analysis of data relating to the natural world, typically as part of a collaborative project with professional scientists. The scientific method is a body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge. It involves making observations, forming questions based on those observations, creating a hypothesis, developing testable predictions, gathering data to test predictions, then refining, altering, expanding, or rejecting the hypotheses to develop general theories.

A BioBlitz is an intense period of biological surveying in an attempt to record all the living species within a designated area. Groups of scientists, naturalists, and volunteers conduct an intensive field study over a continuous time period. One way to collect data during a BioBlitz is by using the application iNaturalist. Using this application, you can record encounters with other organisms, help scientists understand when and where organisms occur, connect with experts who can identify the organisms you observe, and learn about nature.

Participating in citizen science and doing a BioBlitz can teach us about the biodiversity of an area. Biodiversity typically measures variation at the genetic, species, and ecosystem level, and is important because it can keep an ecosystem balanced or working properly. Ecosystem productivity thrives when each species, no matter how small, all have an important role to play. For example, a larger number of plant species means a greater variety of food sources for bugs, which can pollinate the plants and provide food for a larger number of birds. The more biodiverse an area, the better the chances are for long term sustainability for all life forms.

Activity Procedure

(Estimated Time: 1 hour in addition to the film)

1. Find a location for a BioBlitz, like a school yard, park, field trip, etc.

2. Explain how a BioBlitz works using the prompts below.

a. Students will be citizen scientists, but what is a citizen scientist?
b. Using the citizen science application iNaturalist, they will be contributing observation data to a large international database. This database is created by the contributions of other citizen scientists around the world whom also collected data using the application.
c. They will be taking photos of flora and fauna and uploading it to this database. Scientists will then be able to review their photo uploads to identify the organisms and its location.
d. This information will help show patterns of the biodiversity and population in the area.

3. Practice using the application. Students can take close up photos of plants and animals following the prompts in the application. Make sure they fill out all the fields for each photo so the most accurate data is collected.

4. Get started! How many observations can the students make in a half-hour to an hour?

5. When you are back in the classroom, discuss what the students saw and learned.

a. What types of plants and animals did they see?
b. What was the surveyed environment like?
c. Did humans impact this area in any way? If yes, how do they think this affected the plants and animals in the area?
d. What type of scientists do they think will be interested in their data?

Diving Deeper

Find more citizen science projects and activities to engage your class with by checking out the online citizen science project databases Zooniverse.com and SciStarter.com.

Additional Resources

- iNaturalist - https://www.inaturalist.org/
- Sci Starter - https://scistarter.com/
- Zooniverse - https://www.zooniverse.org/projects?page=1&sort=-classifiers_count&status=live

Glossary

3D Modeling - the process of developing a mathematical representation of any surface of an object in three dimensions via specialized software.

Acid - containing acid or having the properties of an acid; in particular, having a pH of less than 7.

Agriculture - the science or practice of growing crops or raising animals.

Alkaline - having the properties of an alkali; having a pH greater than 7.

Angular momentum - the quantity of rotational motion of a moving body, measured as a product of its angular velocity and rotational inertia.

Angular velocity - the time rate at which an object rotates or revolves around the axis of rotation.

Anthropogenic - originating in human activity.

Axis of rotation - the straight line through all fixed points of a rotating rigid body around which all other points of the body move in circles.

Base - a substance capable of reacting with an acid or accepting or neutralizing hydrogen ions.

Baroque - relating to or denoting an architectural style originating in 16th-century Italy and lasting, in some regions, until the 18th century with origins in the Counter-Reformation of the Catholic Church.

BioBlitz - an intense period of biological surveying in an attempt to record all the living species within a designated area. Groups of scientists, naturalists and volunteers conduct an intensive field study over a continuous time period.

Biodiversity - the variety of life in the world or in a particular habitat or ecosystem.

Calcium carbonate - a white, insoluble solid occurring naturally as chalk, limestone, marble, and calcite, and forming mollusk shells and stony corals.

Carnival – large, public celebration taking place at a regular time each year, featuring music and dancing.

Catedral de la Habana - (Catedral de San Cristobal) is one of eleven Catholic cathedrals in Cuba. It is located in the Plaza de la Catedral on Calle Empedrado, between San Ignacio y Mercaderes, Habana Vieja. The 30-by-49-meter rectangular church serves as the seat of the Roman Catholic Archdiocese of San Cristobal de la Habana.

Chemical fertilizers - man-made materials applied to soil or plants to supply additional nutrients needed for growth, often containing nitrogen, phosphorus, and potassium.

Chemical reaction - a process that involves rearrangement of the molecular or ionic structure of a substance, as opposed to a change in physical form or a nuclear reaction.

Citizen science - the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists.

Climate - the average weather conditions in a particular area in general or over a long period.

Comparsas - group of singers, dancers, and musicians that perform choreographed routines

Conga – also known as tumbadora in Cuba; a tall, narrow, low-toned drum beaten with the hands.

Constraint - a limitation or restriction.

Control variable - the experimental element which is constant and unchanged throughout the course of the investigation in order to test the relative relationship of the dependent and independent variables.

Coral - hard, stony substance made by polyps as an external skeleton, typically forming large reefs in warm seas.

Coral colony - many coral polyps connected to one another, creating a cluster of polyps that acts as a single organism.

Coral skeleton - the hard, stony calcium carbonate structure secreted and built upon by living coral animals.

Data – facts and statistics collected together for reference or analysis.

Database - a structured set of data held in a computer, especially one that is accessible in various ways.

Embargo - a government order prohibiting the movement of merchant ships into or out of its ports.

Energy transference - the process by which energy is relocated from one system to another.

Environment - the surroundings or conditions in which a person, animal, or plant lives or operates.

Fauna - the animals of a particular region, habitat, or geological period.

Floor plan - a scale diagram of the arrangement of rooms in one story of a building.

Flora - the plants of a particular region, habitat, or geological period.

Force - any interaction that, when unopposed, will change the motion of an object.

Friction - the resistance that one surface or object encounters when moving over another.

Gardens of the Queen (Jardines de la Reina) – an 840-square mile archipelago in the southern part of Cuba, named by Christopher Columbus to honor the Queen of Spain, Isabella I of Castile. It was established as a marine reserve in 1996 and determined a national park in 2010. It is one of Cuba's largest protected areas.

Gravity - the force that attracts a body toward the center of the earth, or toward any other physical body having mass.

Innovative - introducing new ideas; original and creative in thinking.

Limestone - a hard sedimentary rock, composed mainly of calcium carbonate or dolomite, used as building material and in agriculture.

Magnetic force - two objects that are either attracted or repulsed by each other based on their directional charge.

Marine Protected Area (MPA) – large bodies of water that are protected in various ways, ranging from wildlife refuges to research facilities. MPAs restrict human activity for a conservation purpose, typically to protect natural or cultural resources.

Marine reserve - a type of marine protected area (MPA) often located within larger, multiple-use MPAs. Some zones of multiple-use MPAs, also called marine sanctuaries, permit extractive activities.

Mass – a coherent, typically large body of matter with no definite shape.

Motion - the action or process of moving or being moved.

Music – the science or art of ordering tones or sounds in succession, in combination, and in temporal relationships to produce a composition having unity and continuity.

Musical instrument – an object or tool used to produce sounds in a specific way to create music.

Mutualistic relationship - a symbiotic relationship, long-term interaction between two different species, where both species benefit from the interaction.

Neoclassical (Neoclassic) - relating to or constituting an architectural style that began in the mid-18th century that features a revival or adaptation of the classical architecture.

Neutral pH- chemical solution that is neither acidic nor alkaline (has a pH of 7.0), such as pure water.

No-take zone - a Marine Protected Area (MPA) permanently set aside from direct human disturbance, where all methods of fishing and extraction of natural materials, dumping, dredging or construction activities are prohibited , from which the removal of any resources, living or dead is prohibited.

Observation - the action or process of observing something or someone carefully or in order to gain information.

Organic - relating to or derived from living organisms, often referred to when producing food using fertilizers of plant or animal origins.

Organism - an individual animal, plant, or single-celled life form.

Paleoclimatology - the study of past climates, especially prior to the widespread availability of instrumental records, often used environmental evidence such as tree rings, coral skeletons, diatoms, ice cores, and sediment layers.

Pattern - an arrangement or sequence regularly found in comparable objects or events.

pH - a figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid, and higher values more alkaline.

Population - a community of animals, plants, or humans

Physics - the branch of science concerned with the nature and properties of matter and energy.

Polyp - an animal with a fixed base, a tubelike body, and tentacles for catching prey.

Recyclable – a waste material that is able to be converted into new materials and objects, saving resources and helping to lower greenhouse gas emissions.

Rotational inertia – also known as the moment of inertia; a property of any object that can be rotated and is a value describing the torque needed to change the rotational velocity of the object around its axis of rotation.

Soil acidification - the buildup of protons in soil, reducing the pH.

Sound – waves of invisible energy that we can hear, caused by vibrations that travel through a medium.

Spawn - the mass of eggs deposited by fishes, amphibians, mollusks, crustaceans, etc.

Species - a group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.

Spillover effect - the idea that the area outside and around a marine reserve eventually profits from the nearby over-production of fish.

Sustainable - conserving an ecological balance by avoiding depletion of natural resources.

Tentacle - a slender, flexible limb or appendage in an animal, especially around the mouth of an invertebrate, used for grasping, moving about, or bearing sense organs.

Torque - a twisting force that tends to cause rotation.

Vibration – a rapid motion back and forth.

Zooxanthellae - photosynthetic algae that lives in most reef-building coral tissues. The corals and algae have a mutualistic relationship.