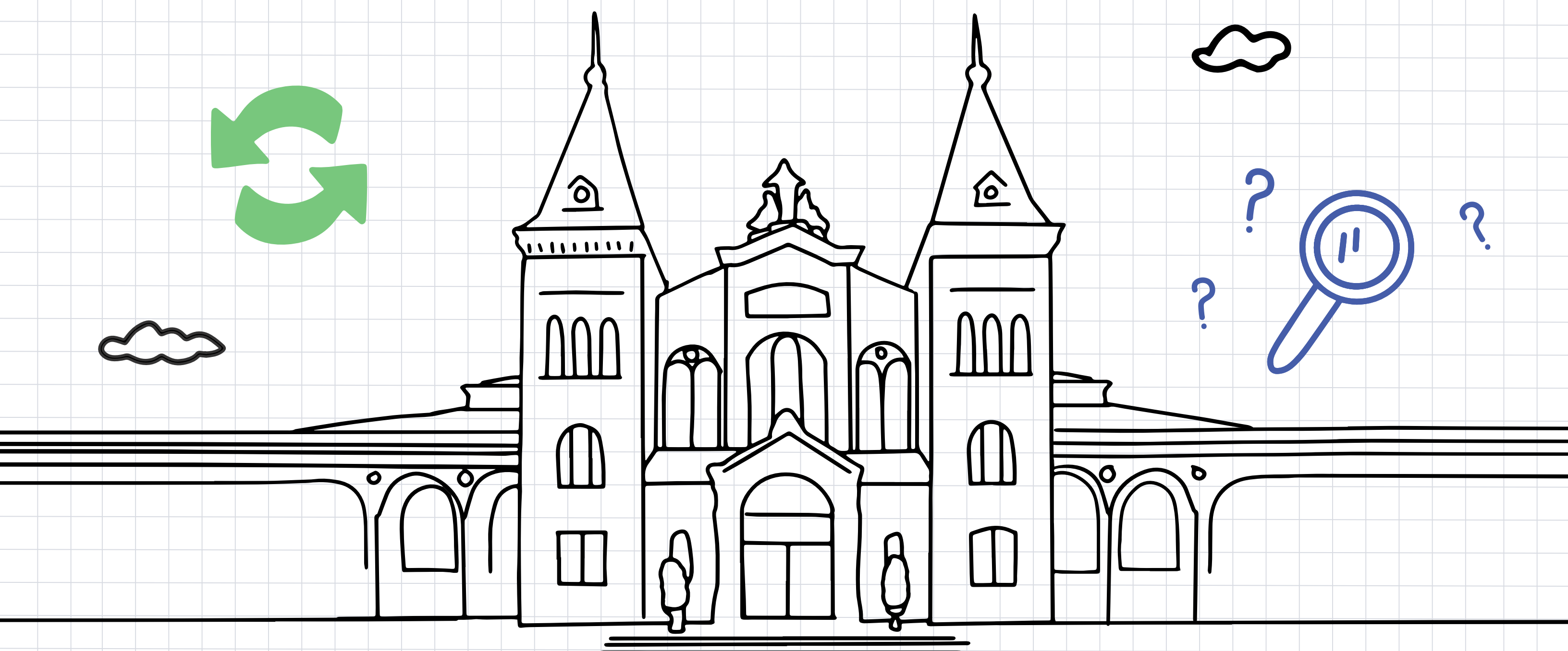
Teacher Toolkit for sustainable FUTURES



ARTS + INDUSTRIES BUILDING
Smithsonian

Smithsonian
Science Education Center

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Contents

Dear Teacher,

The Smithsonian Arts + Industries Building is a hub for creative exchange between ideas and objects from our past and for our future. FUTURES is a multidisciplinary project that features objects and research drawn from the Smithsonian's vast collections and research centers, as well as commissioned artworks, interactive exhibits, and speculative designs, to offer multiple visions for a more hopeful world.

This toolkit is designed to help your students explore the content and themes of FUTURES. It can enhance the experience of an in-person visit or can bring the ideas of FUTURES to your classroom if you're unable to visit in person.

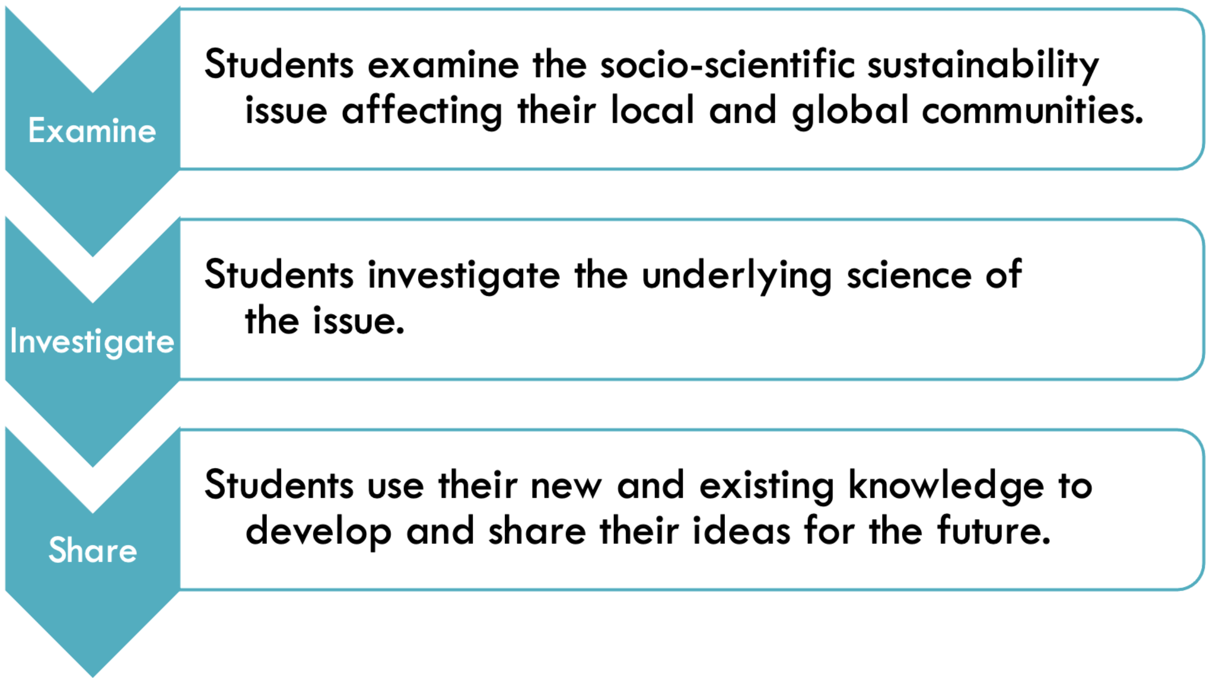
Organized around the concepts of Futures Past, Futures that Work, Futures that Inspire, and Futures that Unite, this toolkit encourages students to embrace their own role, both as individuals and as a community, in shaping the future. It asks students to examine questions about sustainability and relates them to hands-on Common Core and NGSS-aligned activities. This toolkit will not offer a single solution for the future, but instead will ask students to envision and share futures that make sense to them. The toolkit should help students feel that the future is not a fixed destination; it's a decision. We all play a part in making it.

How to Use this Guide

This toolkit is here to help you. This means you can always adapt how you use it to fit your needs and the needs of your students. The activities presented here can be done in any order or combination.

Guide Structure

There are eight activities in this toolkit. Each activity has three sections called Examine, Investigate, and Share. In the Examine sections, students are presented with a question about sustainability. Students focus on understanding background information regarding this question and how the question relates to an object or objects found in FUTURES. In the Investigate sections, students perform an NGSS-aligned hands-on activity relating to the sustainability question. In the Share sections, students put their existing and new knowledge into action by speculating about the future and sharing their ideas and dreams.



Grade Level

This toolkit is designed for grades six through eight and is aligned to middle school Common Core and NGSS standards.

Glossary

At the end of the toolkit there is a glossary of words used that may be unfamiliar to students. These words will appear in bold when they are first used in an activity. Some activities refer directly to the glossary definitions as part of the activity.

Activity Sheets

Each activity in the toolkit has corresponding activity sheets. Activity sheets are labeled; instructions for how many sheets each student or group of students will need for the activity can be found in the materials list for each activity.

Learning Lab

Learning Lab is a free, interactive platform for discovering and collecting objects, tools, and digital resources from across the Smithsonian. Some of the activities in this toolkit include relevant Learning Lab collections. Instructions are provided for how to navigate to these collections and interact with them.

Field Guide to Sustainable FUTURES

Developed in conjunction with this toolkit, the *Field Guide to Sustainable FUTURES* is a printed exhibition guide for visitors ages 10 to 14. When visiting FUTURES, pick up copies at the Welcome Desk.

Learn more about FUTURES

This toolkit presents objects and ideas that explore sustainability. But there is so much more to explore in FUTURES! Visit aib.si.edu to learn more or plan your visit.

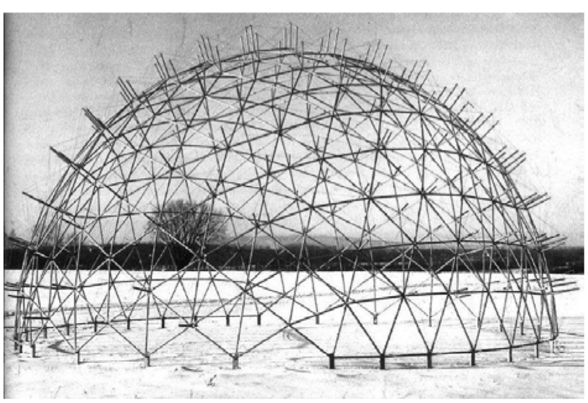
The Smithsonian Team

Futures Past

Can we truly understand the future without understanding our past?

Futures Past presents rarely seen objects from Smithsonian collections to illuminate the many ways people have tried to make a brighter tomorrow. These historical visions shaped the world we live in now, as well as the dreams we have for our own futures. Innovative objects, such as the Bakelizer that produced the first fully synthetic plastic and the marvel of engineering that is the geodesic dome, illustrate the many ways that people have tried to make their own tomorrows brighter.

Not all predictions from the past were accurate, of course, and many had troubling consequences and implications that still resonate today. But, taken together, Futures Past serves as an important backdrop to dreams in the present and lays the foundation for sustainability. Sustainability is the ability to maintain natural resources and to keep an ecological balance. Sustainability is the key to the future. We are, after all, only the latest in a line of future-makers.



"Weatherbreak," Buckminster Fuller's geodesic dome

Bakelizer

Synthetics Sustainability

Examine: How can we preserve natural resources for future generations by reusing synthetic materials?

Look around you and think about what you interact with every day. Think about the objects you see and touch. Did you ever stop to think about what all that stuff is made of? Students will learn about the Bakelizer, which created the world's first plastic, learn how we define natural and synthetic materials, identify what natural resources make up some common synthetic materials, and discuss the sustainability problem of plastic waste and ocean trash. Students then explore artwork made by artists using ocean trash, design their own artwork or device using reused materials, and write a description of their design. Students are inspired to be the latest in a line of future-makers and think of new ways to reuse materials for the health of the planet.

Bakelizer

Investigate

Time: 40 minutes

Materials

For the class

- Computer with Internet connection and projection capabilities and/or individual student devices

For each student

- Synthetics Sustainability Activity Sheet
- Paper
- Writing/drawing implement

Objectives

- Understand what are **synthetic materials** and **natural materials.**
- Understand that synthetic materials are made from natural resources and identify the natural materials that make up common synthetic materials.
- Understand the problem of synthetic materials causing harm to living things.
- Understand that reusing synthetic materials can have a positive impact on the world.
- Make a sculpture or an object from reused synthetic materials to communicate the problem of synthetic materials waste.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-PS1-3
- SEP: Obtaining, Evaluating, and Communicating Information
    - DCI: PS1.A
    - CCC: Structure and Function
- Common Core English Language Arts Standard: CCSS.ELA-LITERACY. WHST.6-8.2

Activity Overview

Inspired by examples of artwork made using ocean trash, students will design their own artwork or object using reused materials.

Procedure

1. Navigate to the Learning Lab collection at https://learninglab.si.edu/collections/futures-synthetics-sustainability/KnG0qDw2k4Mcad8J and project the Bakelizer, or have students navigate to it on their individual devices.
2. Ask students to look closely and describe the object. Based on their observations, ask them to make conjectures about what it might be.
3. Expand the More Info tab and let students read about the Bakelizer. Summarize for students that the Bakelizer was used to create the first synthetic plastic.
4. Draw a T-chart on the board with "Synthetic Materials" and "Natural Materials" as the column headings.
5. Ask students to help define synthetic materials and natural materials.
6. Compare the student definitions with the definitions in the glossary.
7. Using the natural and synthetic materials glossary definitions, ask students to name as many synthetic and natural materials that they can. Write down the materials the students name under the appropriate column headings.
8. After 5 minutes, ask students to focus on the synthetic materials. Remind the students of the definition of synthetic materials (A compound made artificially by chemical reactions). Now students will be identifying the natural material that has been changed to form the synthetic materials listed. Go through the list of synthetic materials. For some it may be easy to identify their natural material base. For example, students will be able to identify that paper comes from wood from trees, but they may not be able to identify the types of metals and other materials in an object like a smartphone. For any synthetic material for which the students cannot identify the natural materials that compose it, assign a student to research the synthetic material online.

9. When the natural material base of all the synthetic materials in the list has been identified, ask the students if they know of any reasons why synthetic materials could be harmful for the planet.

10. Project the Learning Lab collection at https://learninglab.si.edu/collections/futures-synthetics-sustainability/KnG0qDw2k4Mcad8J or have students navigate to it on their individual devices and click through to the Plastic Waste and Ocean Trash Stories section, reading the article titles out loud. (You do not need to navigate to each article, but if you have additional time, this may be valuable.) Have the students brainstorm ideas about why plastic waste and ocean trash are a sustainability problem.

11. Ask students how they feel after reading the headlines about plastic waste and ocean trash and if the headlines have inspired them in any way.

12. Tell students they will now be looking at artwork made from ocean trash. Project the next slide in the Learning Lab collection for the class, or have students navigate to it on their individual devices. Navigate to the website Washed Ashore: From Beach Trash to Ocean Art.

13. As a class or individually, click through the Ocean Trash Art article, including the slideshow of the Washed Ashore sculptures. Ask students to call out any objects they identify in the artwork. Sunglasses, coffee containers, glow stick, and life jacket are some examples.

14. Ask students to reflect on the benefits of the artist reusing materials and what impact reusing synthetic materials has on natural resources. Lead a class discussion offering ideas about how reused materials can be incorporated in things other than art.

15. Hand out a Synthetics Sustainability Activity Sheet to each student.

16. Tell the students that they now will be creating their own design for an object made of reused synthetic materials. The design could be a work of art or a functional item like a flower vase or a pencil holder. They will draw the design in the space provided on the activity sheet.

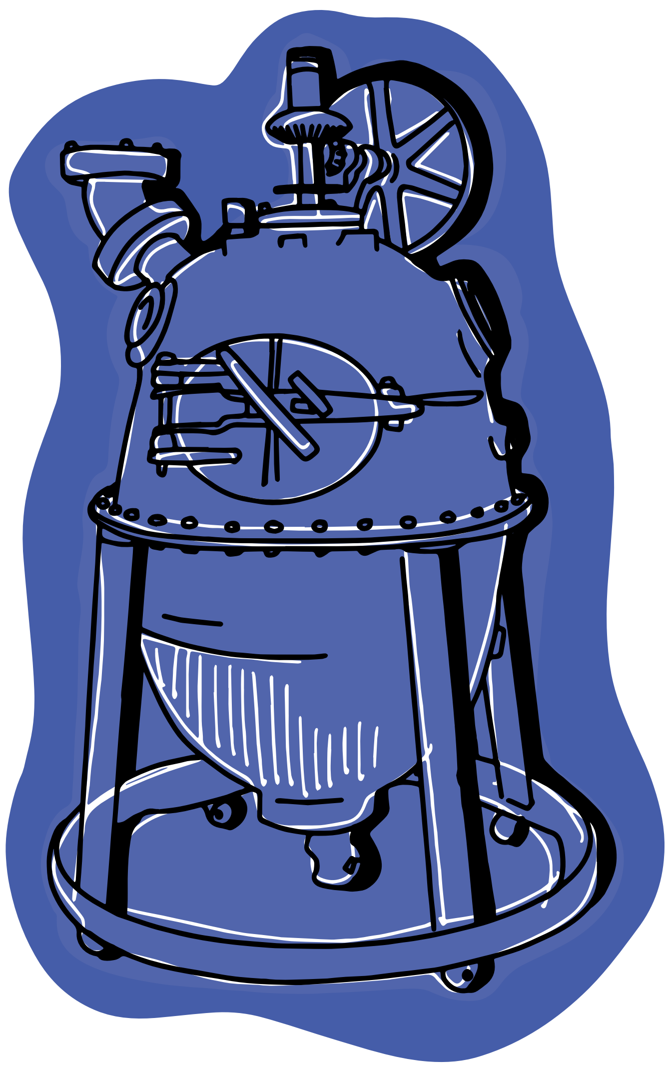
17. Instruct students to list the synthetic materials being used in their design and the natural materials the synthetic materials are made from. Finally, ask students to write a description of their design in the space provided on the activity sheet.

Share

Procedure

Students have just examined synthetic and natural materials. Now, ask them to think about a bigger question: How can we preserve natural resources for future generations by reusing synthetic materials?

1. Instruct students to take out a blank sheet of paper and record their thoughts about the following questions.
    - How can art play a role in preserving natural resources for future generations?
    - How can I, as a future-maker, help solve the problem of ocean trash and plastic waste?

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Synthetics Sustainability Activity Sheet

Draw:

List your materials:

Synthetic Material

____

____

____

____

Natural Material

____

____

____

____

Describe:

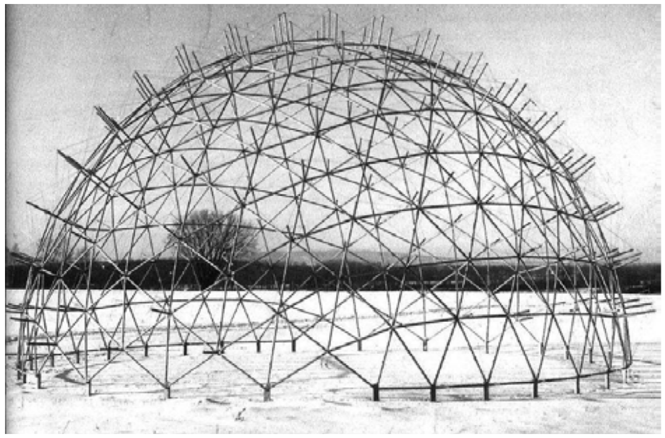
Tough Like an Egg

Examine: How can we build future structures to be sustainable and better resist damage?

What does a strong building look like? You might be surprised, but a dome is one of the strongest shapes for a building. A dome is like the point of an eggshell. Eggshells might seem as if they are brittle, but they are quite strong due to their domed shape. The dome has been used in architecture for centuries. Some of those buildings are still standing today. Because domes are strong, they do not need to be repaired as often as traditional buildings. Another benefit to a domed structure is that they require less materials to build than other building designs. What makes a dome so strong? The shape distributes weight evenly, reducing the load on each point of the dome.

Domed buildings can remain standing for long periods of time due to their shape.

Featured in Futures Past at the Arts + Industries Building, the geodesic dome illustrates how building designs of the past and future use similar engineering concepts to make strong, lasting structures. In this activity students will build and test structure shapes to see which can withstand the greatest amount of force. They will then design a dome with sustainable building in mind.



"Weatherbreak," Buckminster Fuller's geodesic dome

Investigate

Time: Two 30-minute sessions

Materials

For the class

- Computer with Internet connection and projection capabilities and/or individual student devices

For each group of 3 to 4 students

- Testing Structures Activity Sheet, Page 1 and Page 2
- 20 to 30 Marshmallows, gumdrops, or gummy bears
- 40 to 50 Toothpicks or pieces of spaghetti
- Paper plate
- Plastic cup
- Marbles
- Scale (optional)
    - If a scale is not available, use the following weights:

      Paper plate: 19 grams
      Plastic cup: 5 grams
      Marble: 4 gram

- Glue
- Scissors
- Pencil or markers
- Design a Dome Cutout Sheet
- Sheet of blank paper
- Tape

Objectives

- Identify the problem that buildings need to stand for a very long time.
- Design and test two different roof structures.
- Understand how domes can be used as sustainable structures.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-ETS1-2
- SEP: Engaging in Argument from Evidence
- SEP: Developing and Building Models
  - DCI: ETS1.B
  - CCC: Influence of Science, Engineering and Technology on Society and the Natural World
  - CCC: Structure and Function
- Common Core English Language Arts Standard: CCSS.ELA-LITERACY.RST.6-8.3

Activity Overview

Students will build different types of structures, including domes and cubes, and compare their strength, using marbles to test their capacity to withstand force.

Procedure

1. Navigate to ScienceEducation.si.edu/futures-toolkit and show students the images of the geodesic dome. Ask them what they notice and why

someone might want to use this type of structure. After students say what they noticed, point out that the triangles in the dome make it unique.

2. Explain to students that in this activity they will be looking at different building structures and how to test them by adding a downward force. Lead a discussion about building shapes using these questions:
   - What are some very old buildings that have survived until today? What are their shapes?
   - What are some factors that might weaken a building?
   - How can we design strong buildings for the future?
3. Show students the geodesic dome again and ask them what benefits a dome might have. Tell students that domes can be built with parts from a premade kit and that domes are sustainable because they save on costs and materials. They are also sustainable because they enclose the largest volume of interior space using the least surface area. Ask students how domes could be used for sustainable building.
4. Give each group of students the Testing Structures Activity Sheet, Page 1 and Page 2. Have them use the class materials to build three model structures: a dome, a cube, and a unique shape.
5. Let the models sit overnight.

End of the first learning session

6. Have students weigh the paper plate, the plastic cup, and a marble, if a scale is available, and the record the weights on Page 1 of the Testing Structures Activity Sheet. If a scale is not available, have students record the weights listed under Materials.
7. Placing the paper plate face down on top of the structure and the plastic cup face up in the center of the plate, students will slowly add marbles to the plastic cup until each structure breaks. Record how much weight the structure could handle on Page 2 of the Testing Structures Activity Sheet. Repeat this procedure with all three structures. Have students share with the class.

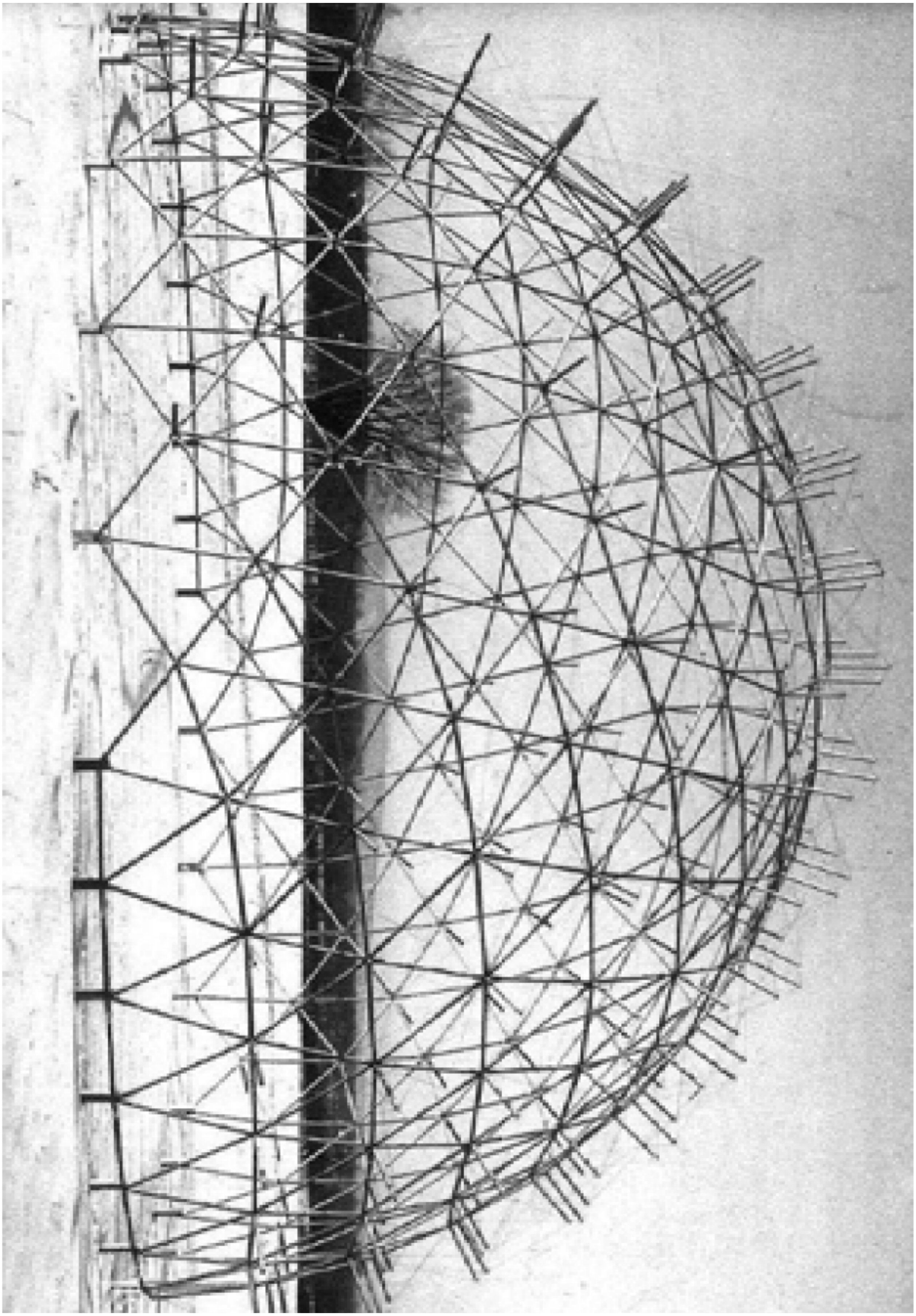
8. Ask students:
   - What were the results?
   - Why does the dome generally do better than the other structures?
   - What is unique about its design?

Share

Procedure

1. Give each group of students the Design a Dome Cutout Sheet. Ask students to design a shelter using the dome cutout and an additional piece of paper.
2. Remind students of their previous discussion on how domes could be sustainable structures. Ask students what they think the interior space of a dome could be used for and what issues in their community could dome structures help with. Encourage students to be inventive in how they design the dome space, with sustainability in mind.
3. To construct their domes, instruct students to:
   a. Cut out the dome covering.
   b. Design their own dome furniture objects to add to the model using a pencil or markers.
   c. Place the dome furniture on a flat sheet of paper and use tape or glue to stick them.
   d. Cut out, fold, and glue the dome covering over the paper with their furniture. Students should be able to show the interior of their structure, like a diorama.

5. Have students share their dome designs with the class and explain how they think their dome addresses sustainability issues.



Testing Structures Activity Sheet, Page 1

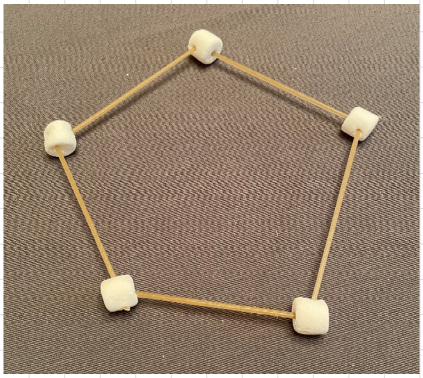
Measure the weight in grams for the following:

Paper plate	**Plastic cup**	**Marble**
___________	___________	___________

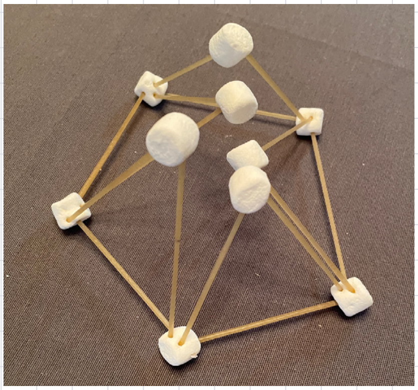
Build three structures using the class materials. One structure should be a dome shape (follow the instructions below), the second should be a cube shape, and the third one is your choice.

Building a Dome

1. Make a pentagon using 5 toothpicks or pieces of spaghetti and 5 marshmallows.

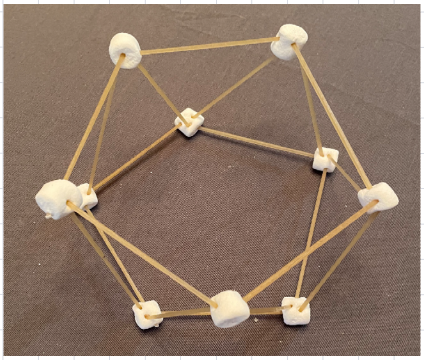


2. Make 5 triangles using 10 more toothpicks or pieces of spaghetti and 5 marshmallows. There should be 2 toothpicks pieces of spaghetti stuck in each marshmallow.

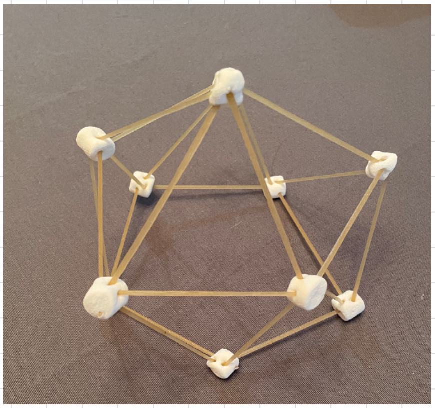


Testing Structures Activity Sheet, Page 2

1. Connect the tops of each triangle using 5 more toothpicks or pieces of spaghetti.



2. Stick 1 toothpick or piece of spaghetti in each of the 5 upper marshmallows and connect them all with another marshmallow.



After creating all three structures, give your structures time for the glue to dry.

Put a paper plate and a plastic cup on top of each structure. Add marbles to the cup one by one until the structure collapses. Add up the final weight that each structure could hold, and record it below

Dome: Final weight (in grams) ________________

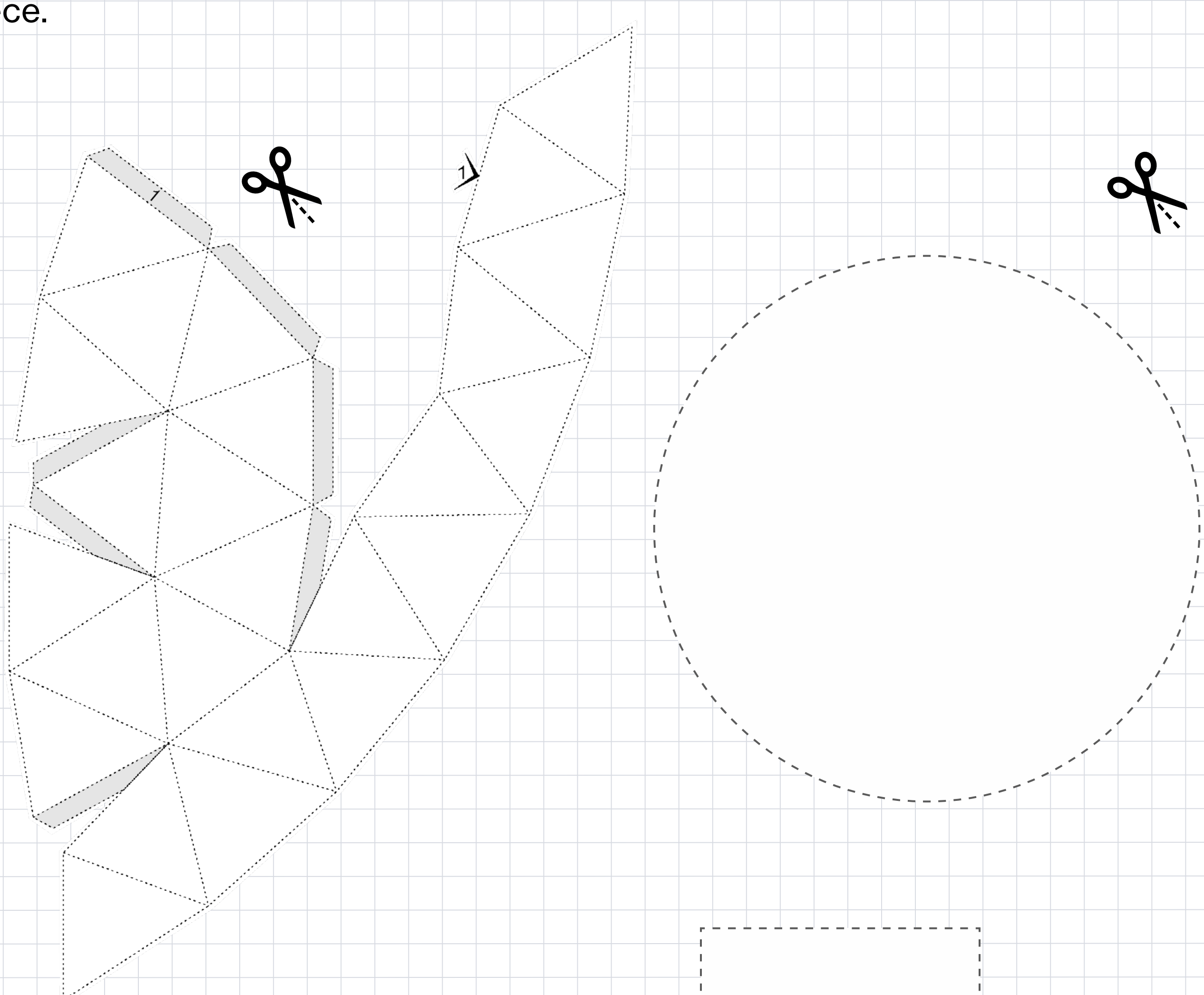
Cube: Final weight (in grams) ______________

My own shape: Final weight (in grams)____________

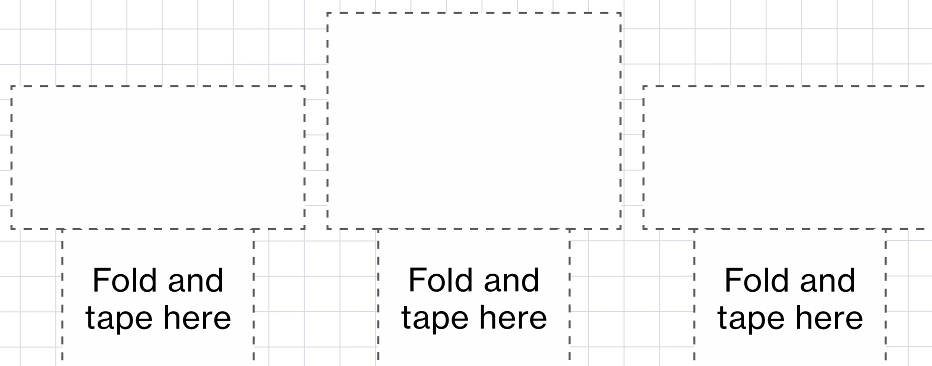
Design a Dome Cutout Sheet

Plan a storm shelter in a dome. What should someone have in their shelter to keep them safe and healthy during a storm?

Dome shell and base: Cut out the circle. Then cut out the shape around the dotted line. Line up tab 1 with the number 1 on the shape. Glue together the tabs with their opposing triangles. Place the shape on top of the circle floor piece.



Create your own dome furniture. Cut out, design, fold and tape down.



Futures that Work

Futures that Work focuses on possible ways of making a healthier, happier world. There are plenty of reasons to feel uncertain about the future. Technology moves so fast that we can't keep up with it. **Climate change** threatens the planet itself. Previous generations have worried about their future too – it's part of being human.

What will our world look like in the years to come? This section of FUTURES looks for answers. One possibility is that we simply slow down; faster isn't always better. Another is to find new ways to be efficient. Maybe we'll be smarter in how we use our resources, so we don't use them up. Maybe we'll harness the power of renewable resources, focusing our creativity on sustainable cycles rather than on endless growth. Exhibit objects such as mushroom bricks and fish skin fashion are options for more responsible decisions. If we make more responsible decisions today, the people of tomorrow will be better off.

Fish skin fashion

Mushroom bricks

Sustainable Structures

Examine: How can sustainable materials help combat deforestation?

Sustainability is the ability to maintain natural resources and to keep an ecological balance. Sustainable materials can help humans prevent long-lasting damage to the environment and preserve **biodiversity**. Materials that can be used up or require too much space or resources to produce are **unsustainable**. As the population of consumers grows, communities must be aware of how the materials they need for their homes and businesses might negatively affect their environment in the long term. The good news is that sustainable materials like mushroom bricks can provide a useful and natural alternative to materials like lumber and cement, which, when overused, damage the environment.

Aerial image of deforestation

In Futures that Work, you'll notice mushroom bricks throughout the hall. The Arts + Industries Building used mushroom bricks to build the exhibition cases and platforms.

Mushroom bricks provide an example of how heavy-duty sustainable materials can be used to benefit community infrastructure. Mushroom bricks are sustainable because they are easy to make and do not burden the environment. Mushroom bricks lessen the need for wood construction materials, which helps combat deforestation while supporting a growing population of consumers. In this activity students will investigate two system models: one using unsustainable lumber and another using sustainable materials to support ecological balance.

Mushroom bricks

Investigate

Time: 30 minutes

Materials

For the class

- Computer with Internet connection and projection capabilities and/or individual student devices

For each student

- Sustainable Structures Model Sheet, Page 1 and Page 2
- Scissors
- Sustainable Structures Design Sheet
- Writing/drawing implement

Objectives

- Students develop and use models to demonstrate sustainable and unsustainable systems.
- Students use computational thinking to represent physical variables as they work through a systems module.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-ESS3-3
- SEP: Developing and Building Models
- SEP: Using Math and Computational Thinking
    - DCI: ESS3.C
    - CCC: Cause and Effect
- Common Core English Language Arts Standard: CCSS.ELA-LITERACY.RST.6-8.7

Activity Overview

In this activity students discuss sustainable building materials, then design their own futuristic building using sustainable and recycled materials.

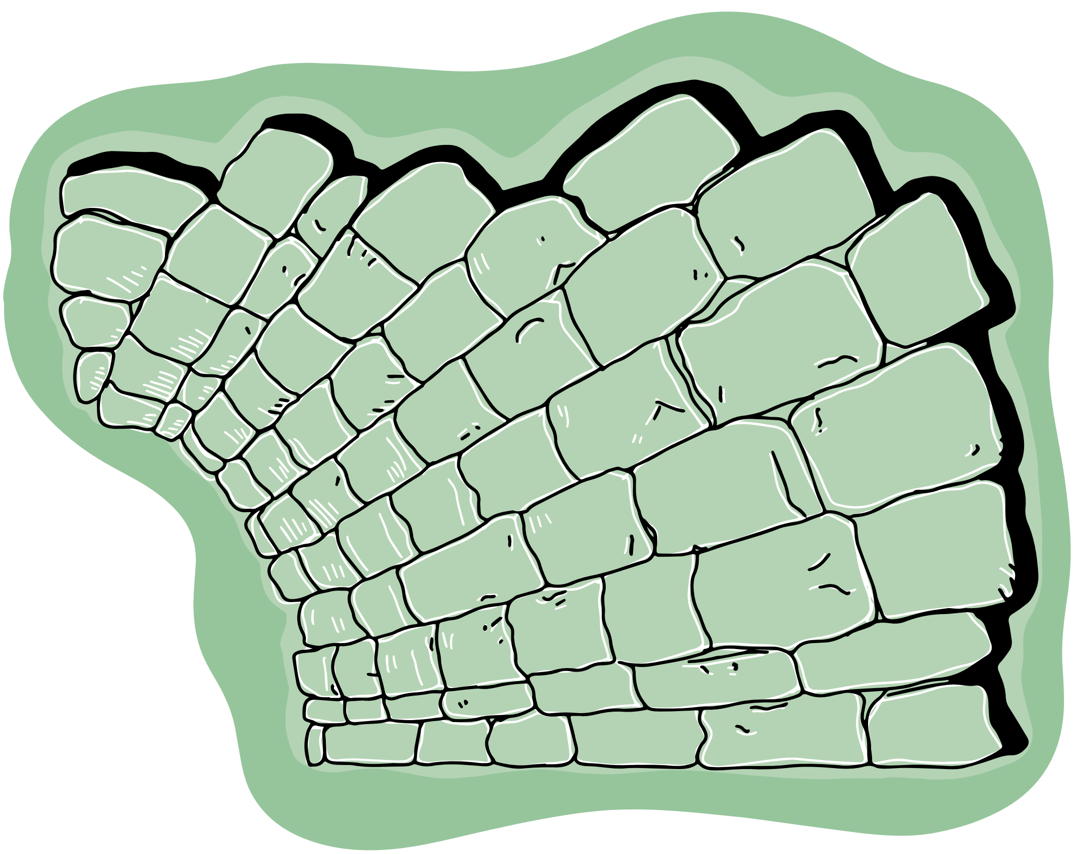
Procedure

1. Ask students to think about the different materials we use to make buildings and what possible negative effects these materials could have on the environment. Lead a discussion with these questions:
   - What are some of the building materials you know of?
   - Where do these materials come from?
   - What happens to the materials after the building is torn down?
   - How can using too much lumber hurt the environment?
2. Now, explain to students that engineers are designing inspiring solutions and have developed a new and sustainable material that is made from mushroom mycelium, which are the root-like structures of fungus. These mushroom bricks are as strong and sturdy as concrete, are **biodegradable**, and can be made faster than it would take to regrow trees. Navigate to ScienceEducation.si.edu/futures-toolkit and how students the image of mushroom bricks and discuss:
   - How do you think sustainable materials like mushroom bricks could help the environment?
   - What other sustainable materials could be used for construction?
3. Give each student the Sustainable Structures Model Sheet, Page 1 and 2.
4. Have each student follow the instructions on the model sheet. They will need to cut out the mushroom and tree pieces and use those pieces to complete the activity.
5. After completing the activity on the model sheet, have students share their thoughts on following questions:
   - How does using mushroom bricks instead of lumber help the forest?
   - What would happen if you relied too much on the lumber instead of the mushroom bricks?
   - Mushroom bricks are considered a sustainable material. What do you think that means?

Share

Procedure

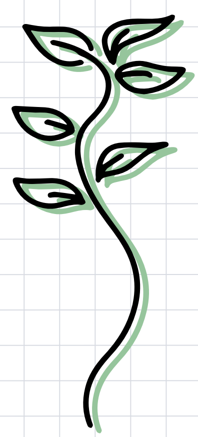
1. Give each student a copy of the Sustainable Structures Design Sheet.
2. Instruct students to design a futuristic building from the list on the design sheet, using the sustainable and recycled materials listed. Students may need to access the Internet to see images of the materials or for inspiration.
3. Have students sketch their designs and share them with others. Encourage them to be inspired by a design problem that they know about and harness their power as future-makers.



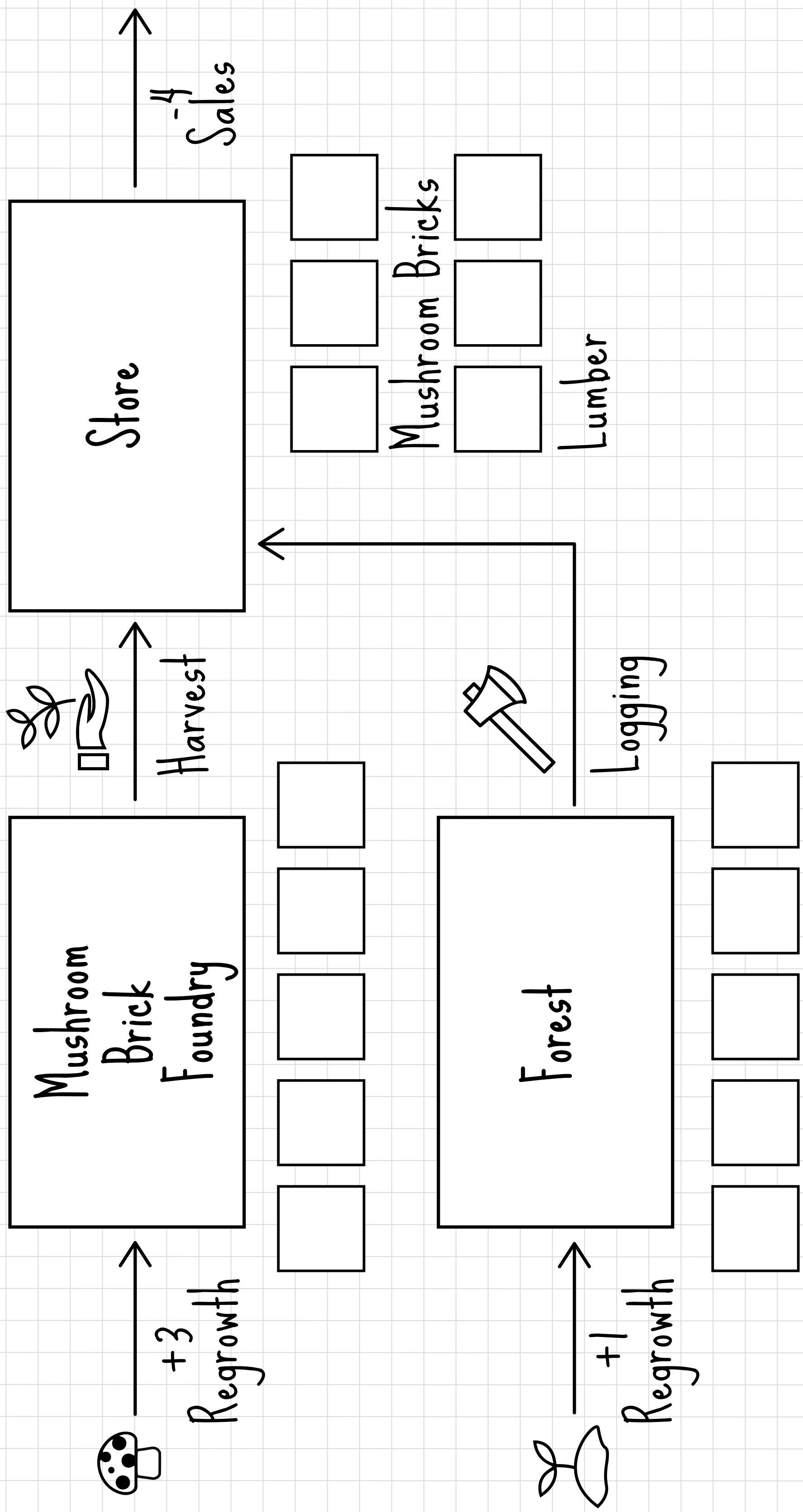
Sustainable Structures Model Sheet, Page 1

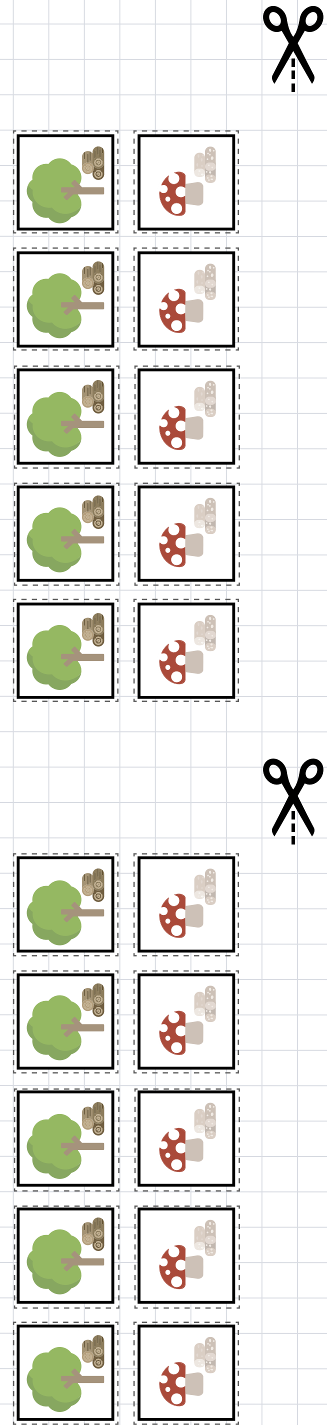
Directions:

1. Cut out the 10 trees and the 10 mushrooms from Sustainable Structures Model Sheet Page 2.
2. Place 5 mushroom pieces in the squares under the mushroom brick foundry and 5 tree pieces in the squares under the forest.
3. Move 3 mushrooms from the mushroom brick foundry to the store. These pieces have been turned into mushroom bricks.
4. Move 3 tree pieces from the forest to the store. These pieces have been turned into lumber.
5. Using the sales number, select any 4 pieces to remove from the store. These are the resources that are sold. Start a new round.
6. At the beginning of each round, add to the mushroom brick foundry and the forest resources using the regrowth number (3 for the mushroom brick foundry and 1 for the forest). Fill up the store with 3 of each resource again. Then sell off 4 resources. Keep repeating rounds until you can answer these questions:
    - What happens to the model if you sell mostly lumber rather than mushroom bricks?
    - What happens to the model if you sell mostly mushroom bricks rather than lumber?



Sustainable Structures Model Sheet, Page 2





Sustainable Structures Design Sheet

Directions:

1. Choose one of the following futuristic buildings:
   - Spaceport
   - Vertical urban farm
   - Robot factory
   - Virtual reality center
   - Be creative and think of your own futuristic building
2. Design your futuristic building using the sustainable and recycled materials listed at the bottom of the page. Make sure you identify on the sketch what materials you used.

Draw:

Sustainable and Recycled Materials

Mushroom bricks	Recycled glass
Recycled metal roof	Rammed earth bricks
Bamboo	Recycled timber
Terracotta shingles	Living roof

Fashion Forward

Examine: How can we make the future of fashion sustainable?

When it comes to clothes and accessories, we often do not pay attention to the materials they're made from or the places they come from. Clothes can play an important part in not only making us look good and sharing our identity, but also in helping the environment. New materials made from sustainable sources, including recycled and waste products, are letting us see how the future will dress in an environmentally conscious and ethical way.

Fashion waste

Located in Futures that Work, Elisa Palomino's fish skin fashion designs demonstrate how locally sourced waste products can be used as sustainable and fashionable material for clothes and accessories. Fish skin has been used in Indigenous communities to make clothing for centuries and is now being appreciated more widely for its **sustainability**. In this activity, students will investigate what materials make up everyday clothes. They then evaluate the difference between those materials and sustainable ones like fish skin. Students will then design a futuristic fashionable outfit using their selected sustainable materials.

Investigate

Time: 30 minutes

Materials

For the class

- Computer with Internet connection and projection capabilities and/or individual student devices

For each group of 3 to 4 students

- Fashion Forward Investigation Checklist Page 1 and Page 2
- Assortment of clothes and other fabric items, with materials tags attached
- Fashion magazines (optional)

For each student

- Fashion Forward Design Sheet
- Colored pencils or crayons

Objectives

- Students plan and carry out an investigation into which common materials are used to make clothes and how sustainable they are.
- Students design a futuristic outfit using only sustainable materials.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-ESS3-3
- SEP: Constructing Explanations and Designing Solutions
    - DCI: ESS3.C
    - CCC: Influence of Science, Engineering, and Technology on Society and the Natural World
- Common Core ELA Standard: CCSS.ELA-LITERACY.RST.6-8.7

Activity Overview

In this activity, students investigate the common materials that make up our clothes and evaluate those materials using a sustainability score. They then work on designing a futuristic outfit using sustainable materials.

What might clothing of the future look like?

Procedure

1. Explain to students that this activity will be looking at fashion and sustainability. Lead a discussion on fashion by asking students:
   - What are some common materials found in clothes?
   - Why do you think there is a growing concern that many of the materials we use for clothing can hurt the environment?

2. As a class, review the glossary definitions of **synthetic material** and **natural material** and ask students to keep these definitions in mind as they look through the Learning Lab collection.

3. Navigate to the Learning Lab collection at https://learninglab.si.edu/collections/futures-fashion-forward/IG0LkZRH7rwvoPQi and project the Sustainable Ideas in Fashion section, or have students navigate to it on their individual devices. Click through the section, reading the headlines or full articles (time permitting).

4. Give each group of students the Fashion Forward Investigation Checklist Page 1 and Page 2 .

5. Have students complete the checklist using three different types of clothes and fabrics from the items you provided.
6. After completing the checklist, have students share their findings with others. Ask them to rank the clothing materials they examined from most sustainable to least sustainable.
7. Make sure students understand that a high score means the fabric is more sustainable and a low score means it is less sustainable. Ask students:
    - Which piece of clothing had the highest sustainability score?
    - Which piece of clothing had the lowest?

Share

Procedure

1. Navigate to the Learning Lab collection at https://learninglab.si.edu/collections/futures-fashion-forward/IG0LkZRH7rwvoPQi and project the Native American Fish Skin Clothing Objects section, or have students navigate to it on their individual devices. Click through the section for historical inspiration for sustainable fashions.
2. Give each student the Fashion Forward Design Sheet.
3. Have each student select a Fashion Forward Design Challenge to sketch and color. Make sure each student labels which sustainable fabric(s) they would use in their future outfit. It might be helpful to provide outfit examples from magazines or websites for students to base their designs on.
4. After students complete their Fashion Forward Design Sheet, have them share their designs with the class.
5. Time permitting, navigate to the Learning Lab collection at https://learninglab.si.edu/collections/futures-fashion-forward/IG0LkZRH7rwvoPQi and project the Sewing Salmon Video Series. Watch the collection of 10 short videos on Indigenous fish skin sewing techniques.

Fashion Forward Investigation Checklist Page 1

Type of clothing			
A fabric found on the tag			
Is the material produced by a living animal? (Yes = -3; No or Don't know = 0)			
Is the animal killed only for this material? (Yes = -3; No or Don't know = 0)			
Is the material left over or the waste product from the dead animal? (Yes = +3; No or Don't know = 0)			
Does the animal require a lot of resources, such as land, water, and food? (Yes = -3; No or Don't know = 0)			
Does the material come from plants? (Yes = +2; No or Don't know = 0)			
Does the material require a lot of resources, such as land and water? (Yes = -2; No or Don't know = 0)			
Does the material use synthetic chemicals? (Yes = -5; No or Don't know = 0)			
Is the material recycled? (Yes = +4; No or Don't know = 0)			
Is the material biodegradable? (Yes = +2; No or Don't know = 0)			
Total Score			

Fashion Forward Investigation Checklist Page 2

Common Materials

Leather: Leather usually comes from cattle raised for no other purpose. Cattle require lots of land and resources. The synthetic chemicals used in leather make it not biodegradable.

Wool: Wool usually comes from sheep, who can live on and continue producing this resource. Sheep require land and other natural resources. Wool is biodegradable.

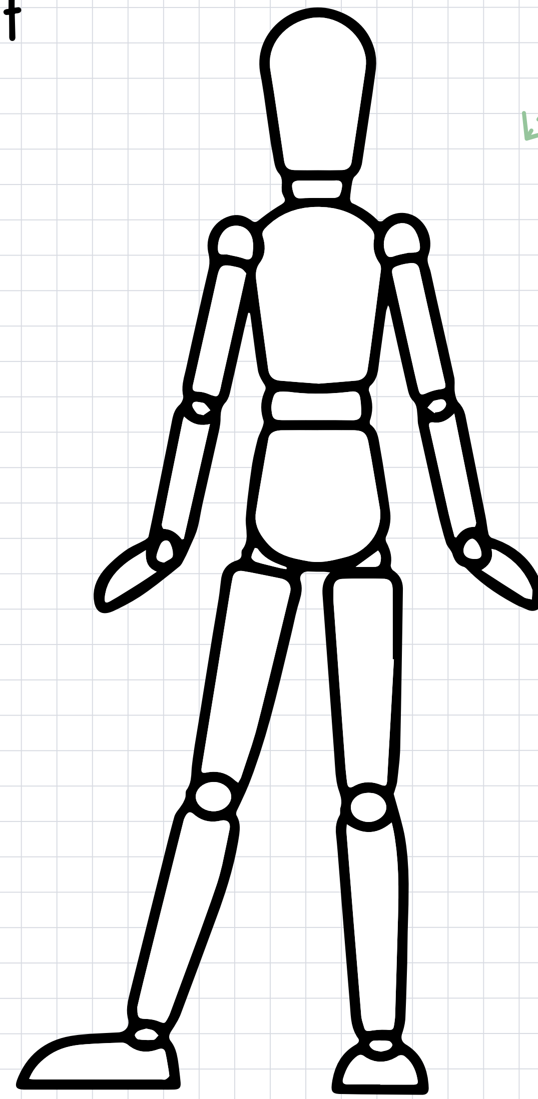
Cotton/Denim: Cotton comes from the cotton plant. The plant requires a lot of water to grow. Cotton is biodegradable.

Linen: Linen comes from the flax plant. It is a hardy plant that requires minimal resources, such as water. Linen is biodegradable.

Polyester: Polyester is a synthetic material that is made from fossil fuels. It is not biodegradable.

Rayon: Rayon is made from the wood pulp of trees. Traditionally, the material requires a lot of land and deforestation to obtain. The synthetic chemicals also used in rayon prevent it from being biodegradable.

Fashion Forward Design Sheet



Design Challenges:

Future Formal
Future Fast Athlete
Future Focused Student

Sustainable textiles:

Fish skin: like cow leather but obtained from the waste product dead fish

Pineapple fiber: like polyester but obtained from the waste product pineapple leaves

Alpaca wool: like sheep wool but requires less resources to produce

Bamboo fiber: Bamboo thread is harvested and woven into light clothing. Recycled cotton: material from old cotton apparel is reused into new clothing.

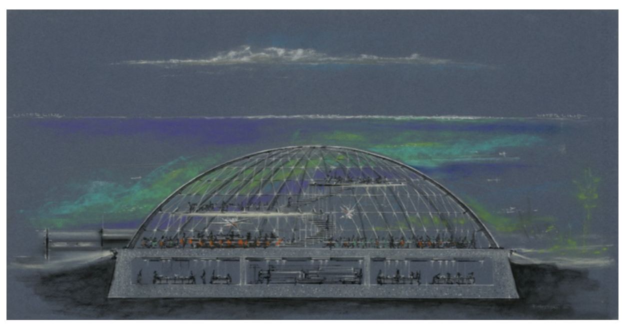
Second-hand clothing

Futures that Inspire

What happens if we approach the future with a spirit of play? Futures that Inspire encourages us to think adventurously and creatively about what might lie ahead. In the brave world of the future, what seems impossible today may become totally commonplace. Imagine new materials, new foods, new species. We may live on other planets or underwater. Computers may help us daydream.

In this section of FUTURES, objects such as the Oceanix City model and Leo Baker's skateboard provide bold ideas about what might lie ahead: ideas that might feel like science fiction; ideas that speak more to our hearts than to our minds. Some of these suggestions may seem improbable, even silly. Giant leaps of imagination often do. As history shows us, it's by dreaming big that reality is reshaped. And the most important inventions can come out of a spirit of play.

Oceanix City model



Undersea Lounge

Leo Baker's skateboard

Change Is in the Air

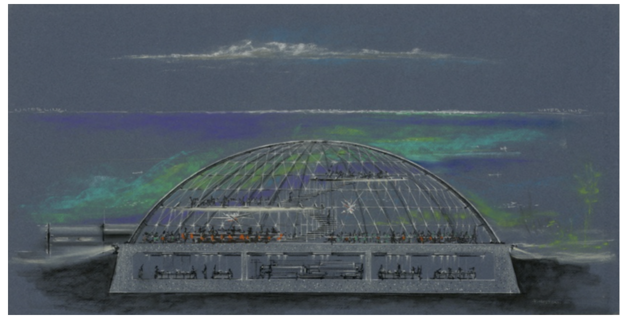
Examine: How can we communicate important scientific findings to our communities?

Radical ideas and extreme engineering can help protect **biodiversity** and people from the dangers of natural disasters. Due to **climate change**, natural disasters are increasing in number and becoming more extreme. Creative solutions are needed to keep communities healthy and growing. But before we start designing solutions to these problems, we first need to understand: What is climate change and how is it caused?

Global warming—one result of climate change—can cause coastal flooding.

Located in Futures that Inspire, the Oceanix City model and the undersea lounge both offer engineering designs for the future where humans can survive and thrive in aquatic environments. These fantastic concepts can remind people about the dangers of rising sea levels associated with climate change, but also help us imagine adventurous and innovative communities of the future. In this activity, students will collect information and construct explanations about the causes and effects of climate change so they can better communicate about the issue with their local communities. Students will then design structures that help support the needs of people and wildlife who are threatened by natural disasters related to climate change.

Oceanix City model



Undersea Lounge

Investigate

Time: 1 hour

Materials

For the class

- Computer with Internet connection and projection capabilities and/or individual student devices
- Scissors

For each group of 2 students

- Climate Change Article Card Set

For each student

- Climate Change Article Activity Sheet
- Climate Change Community Engineer Sheet
- Pencil

Objectives

- Students construct explanations, pulling from multiple sources, to explain the phenomenon of climate change to community members.
- Students design solutions to the problems of climate change that meet specific criteria for preserving biodiversity and a human population.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-ESS3-5
- SEP: Asking Questions and Defining Problems
- DCI: ESS3.D
- CCC: Stability and Change
- Common Core ELA Standard: CCSS.ELA-LITERACY.RST.6-8.8

Activity Overview

In this activity, students will write a news article, after asking questions of an atmospheric scientist, to help their community better understand climate change. Then students will design creative solutions to help protect a community from the effects of climate change while strengthening biodiversity.

Procedure

1. Before the activity begins, cut out one Climate Change Article Card Set for each group of two students. Using the numbers on each card, place each set of cards in order.
2. Lead a class discussion on ways people find out about the news in your community. Ask students:
    - What are some ways we can get the news?
    - Have you ever seen or read about a scientist in the news? If so, what did they speak about?
    - Why is it important to learn about climate change from scientists?

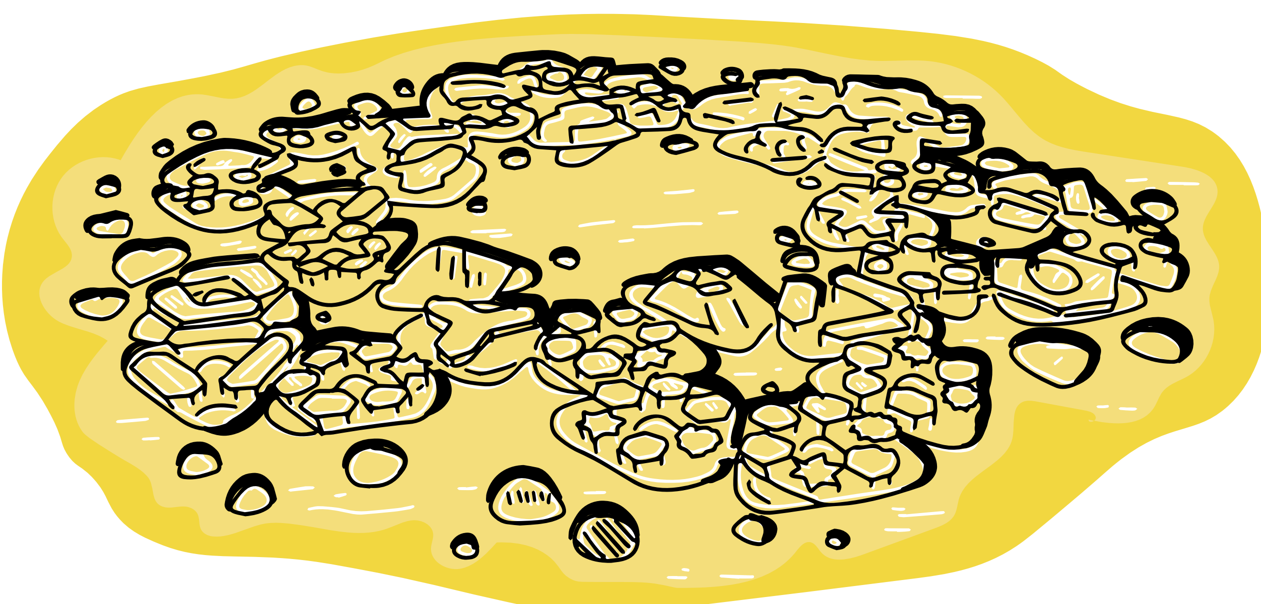
3. Ask students:
    - What do you know about climate change?
    - What questions do you have about climate change?
4. Ask students how they define climate change, then review the glossary definition.
5. Give each group of two students Climate Change Article Card Set Page 1 and Page 2. Give each student a Climate Change Article Activity Sheet.
6. Have one student role-play as the reporter and the other as the atmospheric scientist.
7. Working in pairs, have the reporter read aloud the question. The pair should take some time to try to answer the question between themselves, using their prior knowledge. Then have the student role-playing as the atmospheric scientist read aloud the answer to the question.
8. If students are working alone, have the student read the question to themself and then consider how they would answer the question, using their prior knowledge, before reading the answer card.
9. After completing the question-and-answer activity, have each student write a news article, following the instructions on the Climate Change Article Activity Sheet.
10. Have students share what additional questions they wish they could have asked an atmospheric scientist about climate change.

Share

Procedure

1. Give each student a Climate Change Community Engineer Sheet.
2. Remind students about the effects of climate change they wrote about in their articles. Navigate to ScienceEducation.si.edu/futures-toolkit. Then show students the fantastical examples of the Oceanix City model and the undersea lounge. Discuss how these are solutions for coastal communities to rising sea levels.

3. Inform students that they will now be designing their own solutions to climate change problems. On the Climate Change Community Engineer Sheet, have students select an effect of climate change from the list and sketch an engineered solution for that problem. The more extreme the better!
4. Have students share their engineering solutions and explain how they meet the criteria of addressing a problem associated with climate change.
5. Have students compare their solutions and notice if there are any similarities in how they solved the problems.



Climate Change Article Card Set Page 1

Atmospheric Scientist:

We use natural records to show the temperature changes over the past 100 years. This includes chemicals found in geologic records, tree rings, and ice cores. For a little more than 100 years we have seen a steady increase in temperature around the globe of about 2 degrees Celsius. We call this specific warming phenomenon climate change.

1

1

Reporter:

How has the temperature of the Earth changed over the past 100 years? How do we know?

Atmospheric Scientist:

Yes. Mainly it's human activities, including burning fossil fuels, transportation, deforestation, and sustaining livestock. All these activities release greenhouse gases into the atmosphere.

2

2

Reporter:

Do we know what is causing climate change?

Atmospheric Scientist:

Carbon dioxide is an example of a greenhouse gas. Because of its molecular structure it stays within the atmosphere longer than other gases and keeps the Sun's heat from escaping the Earth. Fossil fuels are materials such as coal, oil, and gas, that formed from the remains of dead plants and animals. Humans use them for electricity, heat, transportation, and other power needs.

3

3

Reporter:

What are greenhouse gases?
What are fossil fuels?

Fold Here

Climate Change Article Card Set Page 2

Atmospheric Scientist:

Climate change will cause more extreme and frequent weather events, such as floods, storms, and heat waves. The ice sheets of the Arctic will melt faster and faster, causing the ocean levels to rise and affecting many coastal cities. Wildlife that cannot adjust to their changing ecosystem will face extinction.

4

4

Reporter:

What will the effects of climate change be?

Atmospheric Scientist:

We cannot get rid of the greenhouse gasses that are in the atmosphere now, but there are some things we can do to prevent the effects of climate change from getting worse. For example, we can change our personal habits that waste energy coming from fossil fuels, such as using less hot water. We can also support changes to the energy system to include more renewable sources, such as solar, wind, and hydropower.

5

5

Reporter:

Is there any way we can stop climate change?

Atmospheric Scientist:

We will need to think of innovative solutions to protect cities that are on the coasts. We will also need to think of ways to help communities better resist floods and heat waves. And we need to think of ways to protect many of the animals and plants that might go extinct. The next generation will need to engineer solutions to these problems.

6

6

Reporter:

What else can we do to prevent damage from climate change?

Fold Here

Climate Change Article Activity Sheet

Collect the information you gathered from your climate change questions. Write a newspaper article for your community explaining what is causing the rise in global temperatures. What are the effects of climate change? What can we do to reduce greenhouse gases?

Write: ______________________________

Climate Change Community Engineer Sheet

Choose a climate change problem from the list below. Design and sketch a radical engineering solution for that problem. Dream big and be wild and adventurous!

- Flooding
- Melting glaciers and sea level rise
- Heat waves and forest fires
- Mass extinctions

Draw:

Skateboarding to Sustainability

Examine: What will transportation be like in the future?

Do you like to travel? What was the last place you went to? What vehicle did you use? Some locations are far away and require very big and fast vehicles, like airplanes, trains, and cars. Most people in the United States travel using gas-powered vehicles, which contribute to climate change. Can you think of any ways to travel that do not emit carbon dioxide? Electric vehicles can help people get around. They use batteries and electric motors to move. Electric vehicles include cars, buses, bicycles, skateboards, and scooters. Other ways to get around that do not emit carbon dioxide include walking, rollerblading, and human-powered cycling.

Traveling on an electric bicycle

Located in Futures that Inspire are many examples of transportation, including jetpacks, superhero tech suits, and a flying car. But other forms of transportation, like skateboards and bicycles, might hold the biggest potential to decrease carbon emissions for our planet. As our society looks to make transportation cleaner and more inclusive, we can be inspired by the example of Leo Baker's skateboard, which shows how everyone has the potential to be involved in a changing transportation perspective.

Leo Baker's skateboard

Investigate

Time: 40 minutes

Materials

For each student

- Calculating Carbon Emissions Worksheet
- Pencil
- Calculator (optional)
- Carbon-Neutral Travel Tips Worksheet
- Design for Transportation Inclusivity Activity Sheet
- Colored pencils or crayons

Objectives

- Understand how electric vehicles work differently from fossil fuel vehicles.
- Identify how electric vehicles and human-powered modes of transportation are better for the environment and the person.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-ESS3-5
- SEP: Asking Questions and Defining Problems
  - DCI: ESS3.D
  - CCC: Stability and Change

- Common Core English Language Arts Standard: CCSS.ELA-LITERACY.WHST.6-8.2

Activity Overview

In this activity, students will help a person in a hypothetical community move from fossil fuel–burning forms of transportation to cleaner options. Students will track the carbon emissions for the community member and suggest how they can change their transportation habits in ways that reduce carbon emissions.

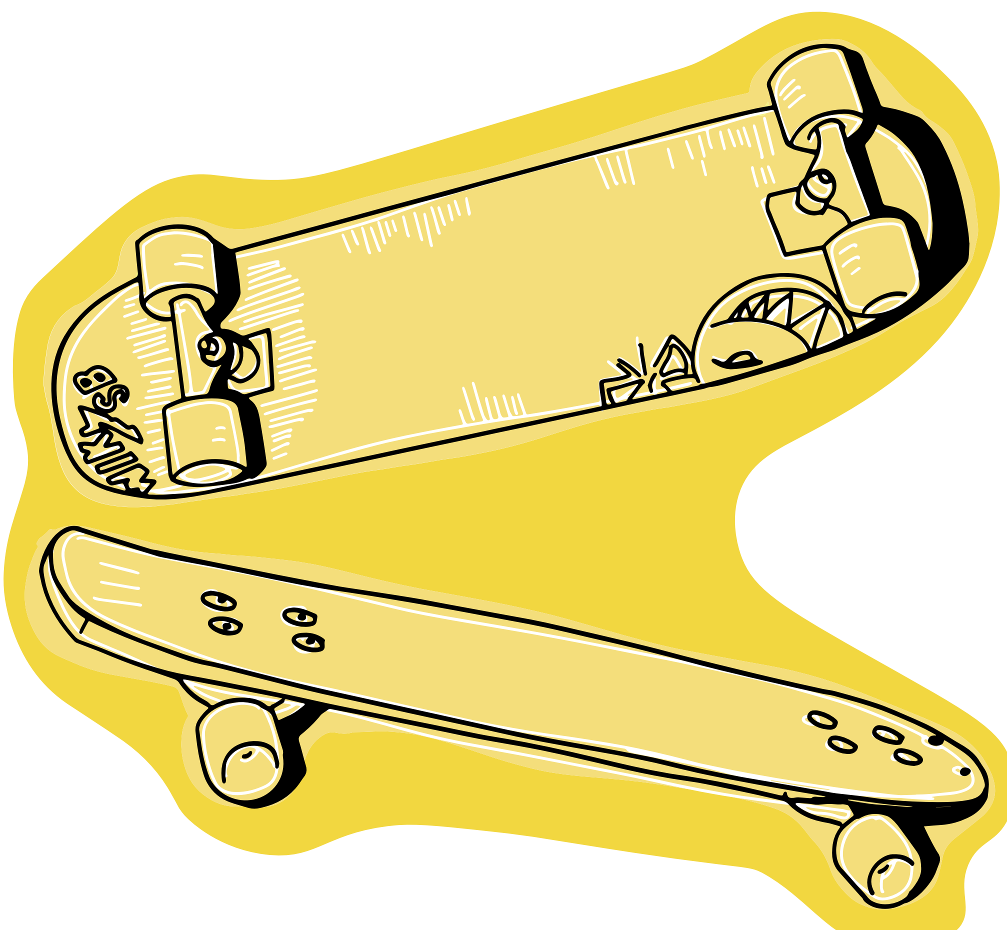
Procedure

1. Explain to students that this activity will be looking at how to track carbon emissions. Lead a discussion about transportation by asking the students:
   - What is the connection between vehicles and climate change?
   - What are some other ways to travel instead of a car?
   - Why do you think more people are trying to travel in ways that do not use gasoline?
2. Give each student the Calculating Carbon Emissions Worksheet and the optional calculator.
3. After they complete both questions on the Calculating Carbon Emissions Worksheet, tell students that there are 1.2 billion cars in world. How does that fact affect their views on climate change and carbon emissions?
4. Give each student the Carbon-Neutral Travel Tips Worksheet.
5. Have students work through the Carbon-Neutral Travel Tips Worksheet. Students should select travel forms for the community member that are alternatives to a fossil fuel–burning car. They will detail those changes and list any additional recommendations for the community member using the new forms of transportation.

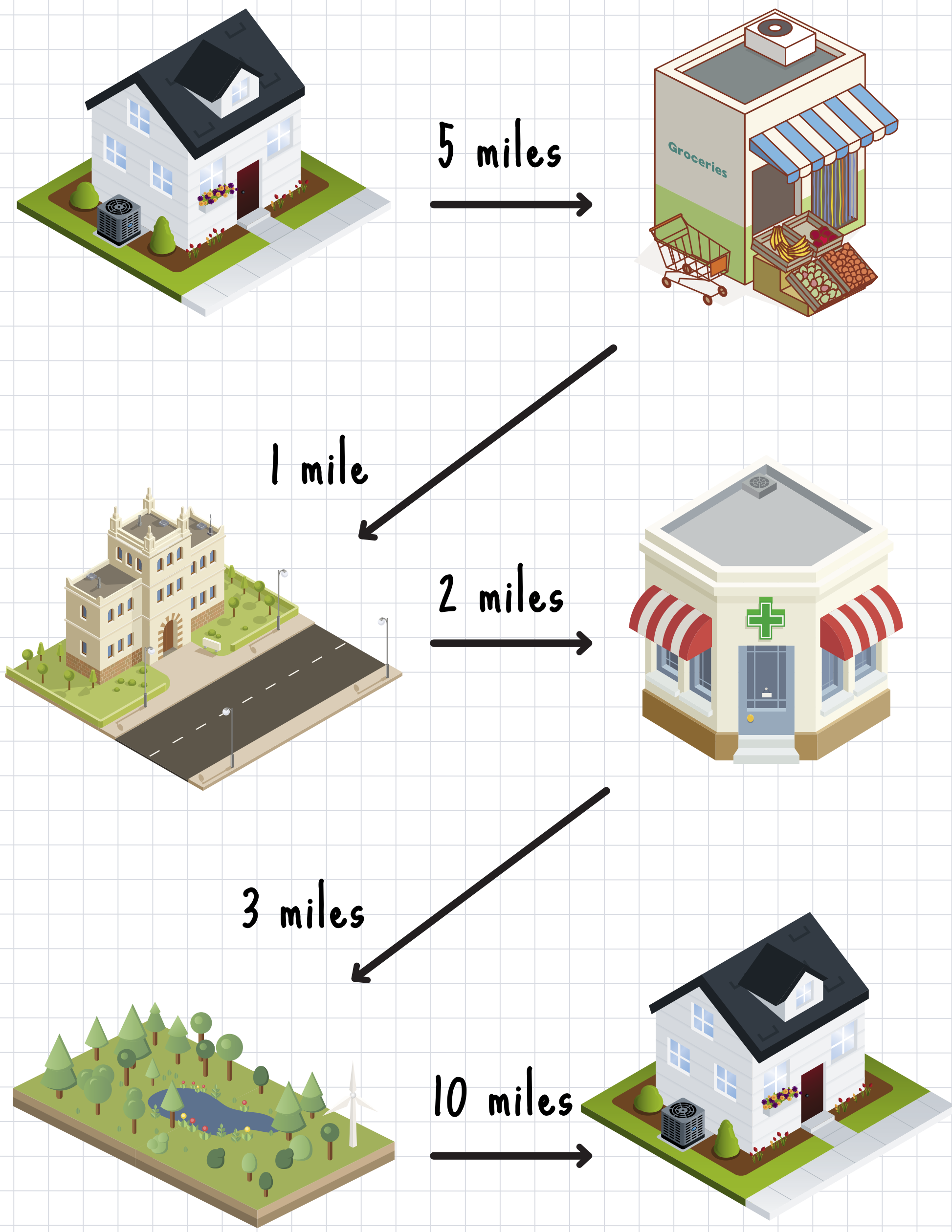
Share

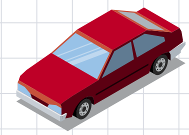
Procedure

1. Give each student a Design for Transportation Inclusivity Activity Sheet and colored pencils or crayons.
2. Share with students how the athlete Leo Baker, who identifies as non-binary, worked to make skateboarding more inclusive and move it away from being seen as a "male" sport. Ask them to design this skateboard with art that speaks to the aim to make clean transportation more inclusive for everyone in the community.
3. Have students share their designs with the class by describing how their design is hopeful and how it helps point to an inclusive future.



Calculating Carbon Emissions Worksheet





The average car emits 404 grams of carbon dioxide per mile. Calculate how much carbon is being generated by all of this community member's trips.

Total carbon dioxide emissions from this community member: _______ grams

This driver lives in a town of 1,000 people who all drive the same distance. How much carbon dioxide is being emitted by the town?

Total carbon dioxide emissions from the town: _______ grams

Carbon-Neutral Travel Tips Worksheet

The community member wants to change from relying on fossil fuel–burning cars to cleaner transportation options. How could this community member use other options to get to some of places they like to travel to? Write out a new travel plan for them using two or three of the options listed below. When you finish creating the new travel plan, recalculate the carbon emissions of the community member, replacing parts of their trips with these carbon-neutral forms of transportation.

Good for Short Trips (2 or fewer miles)

Walking   Rollerblading

Good for Medium Trips (5 or fewer miles)

Electric Scooter   Electric Skateboard

Good for Long Trips (more than 5 miles)

Public Transportation   Electric Bicycle

Replace parts of the community member's commute with carbon two or three carbon-neutral forms of transportation. Recalculate their new carbon emissions.

Total carbon dioxide emissions from this community member:

_______ grams

Describe your recommended reduced carbon emissions travel plan for the community member:

____

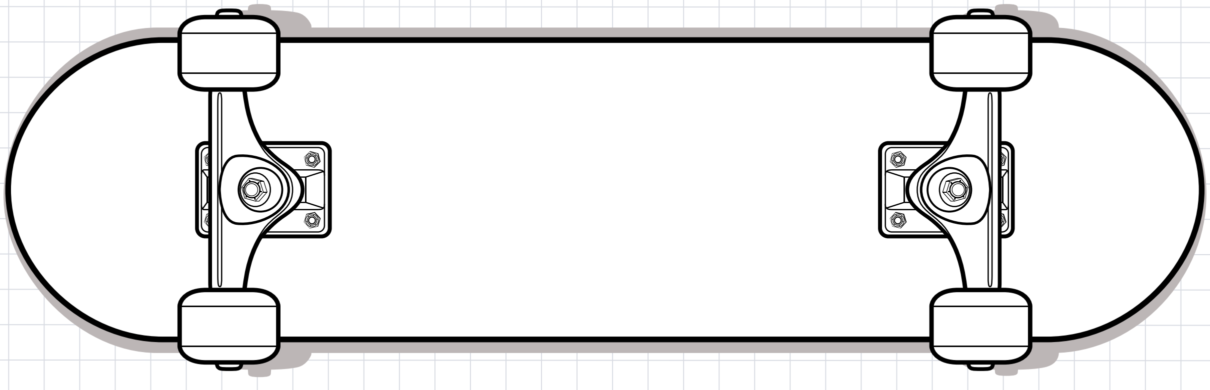
____

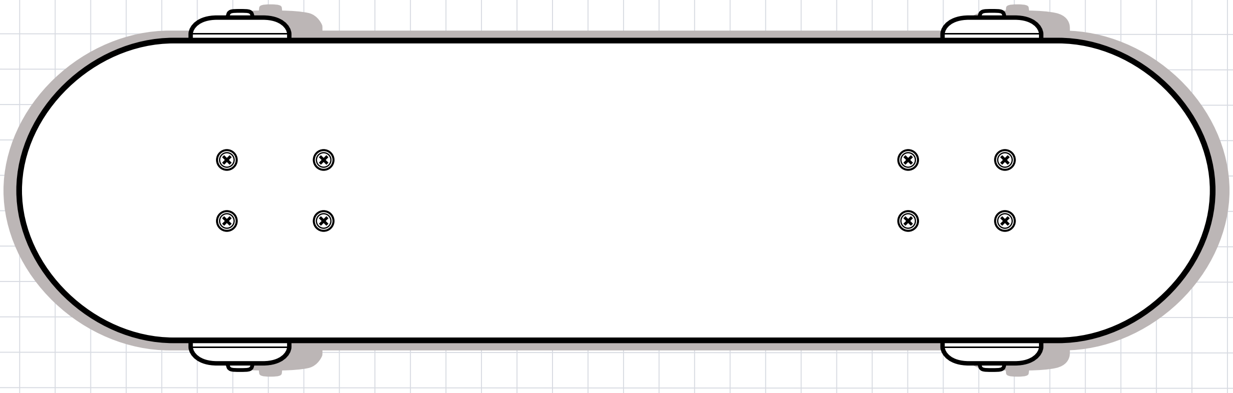
____

____

Design for Transportation Inclusivity Activity Sheet

Skateboarding began as a way for surfers to have fun on day the ocean waves were quiet. Skateboard athletes work on complex tricks. They do ollies, kickflips, and power slides. Many people saw skateboarding as a "male" sport. Athletes like Leo Baker, who identifies as non-binary, are working to make skateboarding more welcoming to everyone. Often, a skateboarder will design their board with art, stickers, and paint to express their ideas and their individuality. On the skateboard below, create a design that shows the importance of including everyone in new forms of transportation.





Futures that Unite

What might “people power” look like in the future? What will it take for us to live in ways that are more equitable, peaceful, and inclusive? Given our diverse perspectives, how can we best make decisions together about our shared future?

This section of FUTURES is all about how we relate to one another. Showcasing programs like citizen science and the Smithsonian Cryo-Initiative, it proposes new ways for us to connect, both face-to-face and across huge distances. Some of these ways of building community are traditional, some technological. Some even involve collaboration with plants, animals, and robots. But all aim for the same goal: to tap into our collective humanity. As we make decisions about the future, perhaps we should place the greatest value on one another.

Citizen science program

Smithsonian Cryo-Initiative

Park Planner

Examine: How can investigating details about our local area help scientists make better decisions?

Supporting local **biodiversity** and **ecosystems** can be a difficult task, especially if you live far away from the area you are trying to protect. Often, scientists use various forms of technology to help them investigate an area they are not in. However, sometimes scientists need help from local community members to provide details and analyze local wildlife to get a better idea of how best to protect the natural environment. These regular people who volunteer their time and resources to help solve big problems are called citizen scientists.

Citizen scientists collect data in the field and report back to researchers.

Located in Futures that Unite, the citizen science exhibit presents the many ways people can engage with and support their local communities by expanding scientific knowledge. A citizen scientist might be asked to search out and count local wildlife or to analyze photographs of animals taken with a camera trap. A citizen scientist will send their data to a researcher to help fill in the biodiversity picture so that communities can make better-informed decisions. In this activity, students will design a vibrant community park that balances the needs of both humans and the natural world.

Investigate

Time: 30 minutes

Materials

For the class

- Computer with Internet connection and projection capabilities and/or individual student devices

For each student

- Park Planner Activity Sheet
- Park Planner Pieces Sheet
- Scissors
- Citizen Science Journal Page
- Pencil

Objectives

- Students record what animals and plants live in their communities and the places where the animals and plants live.
- Students design solutions to problems associated with sharing spaces with local wildlife and people.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-LS2-4
  - SEP: Engaging in Argument from Evidence
  - DCI: LS2.C
  - CCC: Stability and Change
- Common Core Math Standard: CCSS.MATH.CONTENT.7.RP.A.2

Activity Overview

In this activity, students will design a community park that balances the needs of humans, plants, and animals that use the space.

Procedure

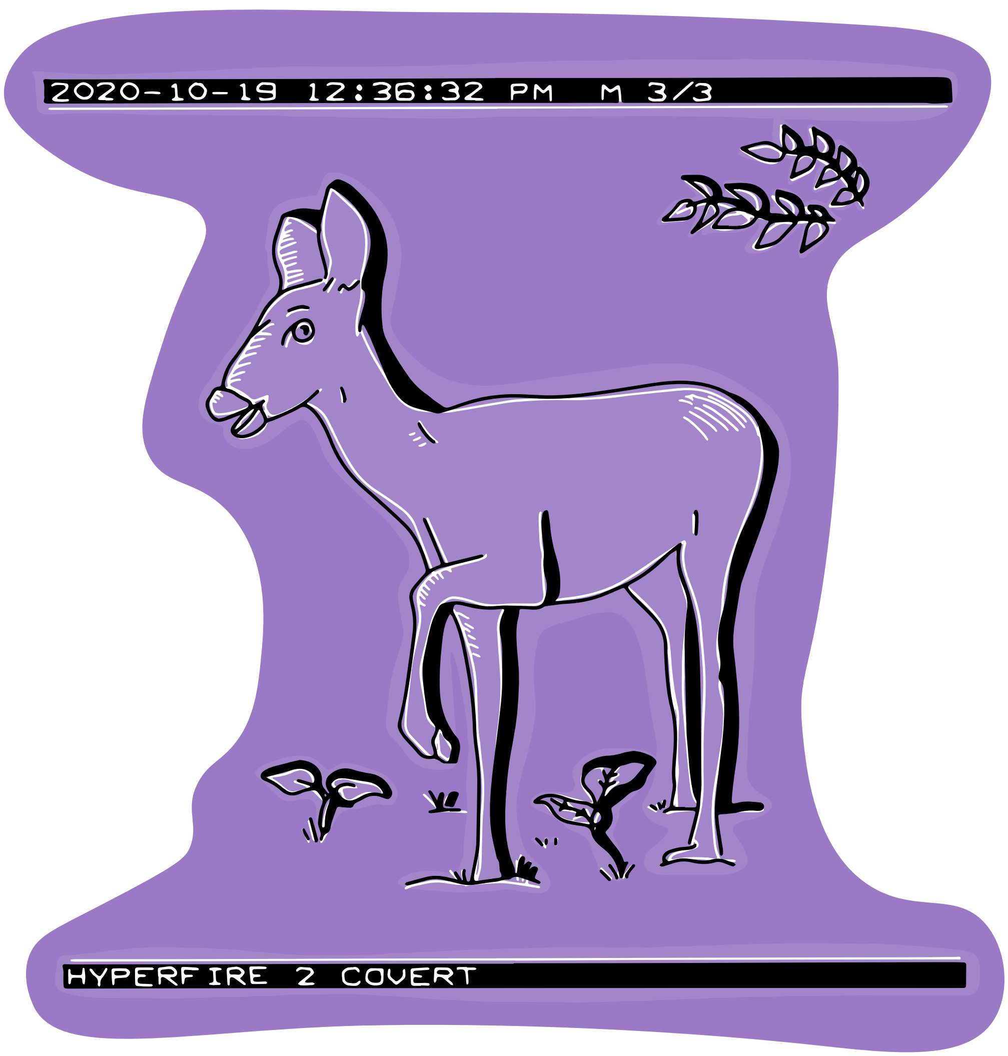
1. Navigate to the Learning Lab collection at https://learninglab.si.edu/collections/futures-citizen-science/nWkKXAMOc2rZsJui and project it for students, or have them navigate to the collection on their own devices.
2. As a class or individually, read through the Smithsonian Citizen Science Projects section.
3. Discuss why scientists might need the help of citizen scientists and what information citizen scientists can provide.
4. Give each student a Park Planner Activity Sheet and a Park Planner Pieces Sheet.
5. Have them cut out the four park objects from the Park Planner Pieces Sheet.
6. Students will read the directions on the Park Planner Activity Sheet to complete the activity.
7. Have students share their park design with others. Ask students to evaluate one another's designs. Do they meet the criteria of the challenge? Does the placement of the objects make sense?

Share

Procedure

1. Navigate to the Learning Lab collection at https://learninglab.si.edu/collections/futures-citizen-science/nWkKXAMOc2rZsJui and project it for students, or have them navigate to the collection on their own devices. Read through the headlines in the Citizen Science Stories for inspiration for citizen science projects. Have students note which plants and animals are being researched.
2. Give each student a Citizen Science Journal Page. Tell the students that they are now going to act like citizen scientists and let scientists know what plants and animals live in their community.

3. Students will read the directions on the Citizen Science Journal Page to complete the activity.
4. Students will sketch out and record details of plants and animals that live in their community.
5. Have students share what plants and animals they wrote about. Discuss the various habitats of these plants animals. Students may need to research some of these details on the Internet. If the students are visiting locations around the community, have them ask permission from an adult or let an adult knows where they are going.

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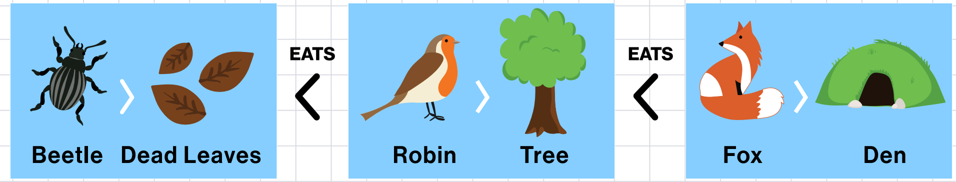
PERFIRE 2 COVERT

Park Planner Activity Sheet



FUTURES PARK PLANNER

Design a vibrant community park balancing the needs of both humans and the natural world.

HOW TO PLAY

1) Place the colorful 3D printed human features within the grid while preserving the animal habitats.

2) Each feature and habitat has a point value based on its impact within the park. The point values are indicated in the map and below.

3) Human features replace animal habitats, so only the habitats that are visible count for points.

4) Not all human features need to be placed.

HINT: *Explore the food chain at the top of the sheet to better understand the animals you are protecting (foxes, robins, and beetles).*

SCORING

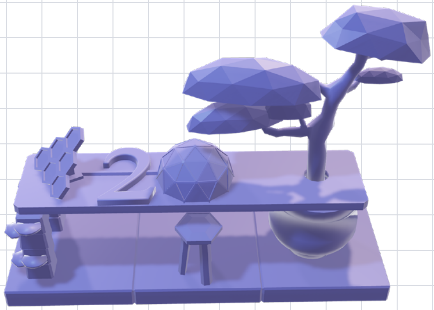
When you're done designing your park, add the values of the human features in your park using the purple counter and the values of the animal habitats using the green counter and compare them.

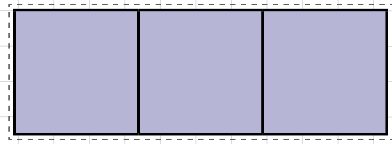
The closer the scores for human features and animal habitats are to each other, the better. That means you've designed a park that balances the needs of all living things. Well done, future-maker!

HUMAN FEATURES

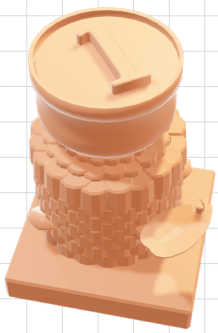
ANIMAL HABITATS

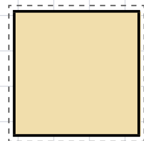
Park Planner Pieces Sheet



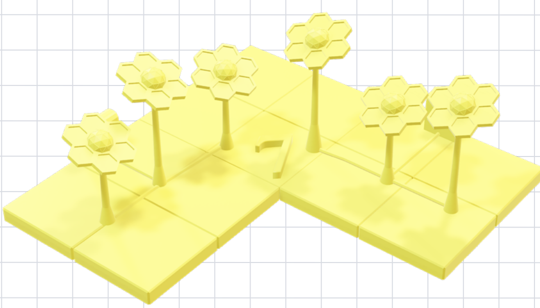


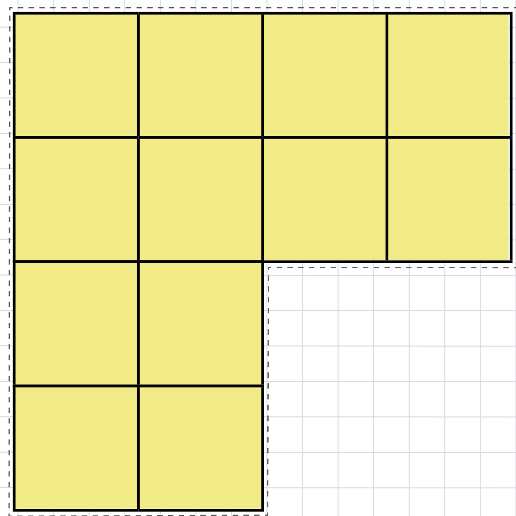
Citizen Science Desk



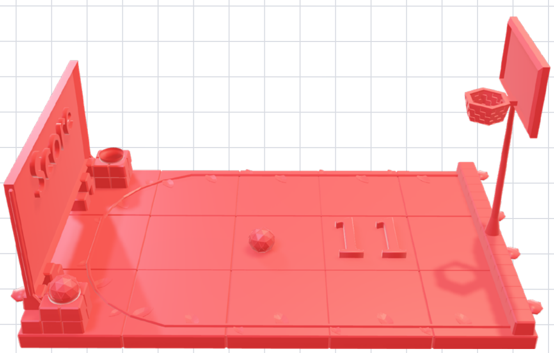


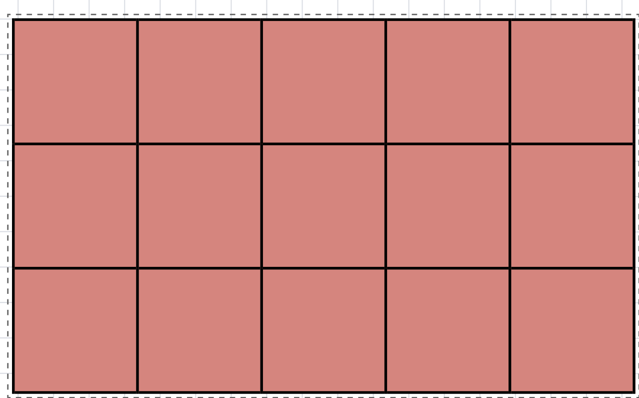
Water Harvester Drinking Fountain





Solar Array





Kinetic Energy Basketball Court

Citizen Science Journal Page

Sketch and detail two animals and/or plants in your community. Write down facts about their location and what makes them special.

Animal or Plant

Where do they live?

Why are they special to you?

Animal or Plant

Where do they live?

Why are they special to you?

Cryo-Creature

Examine: How can we use human technology to preserve biodiversity and save endangered species?

Biodiversity is the variety of life in the world or in a particular habitat or **ecosystem**. Earth's biodiversity is in jeopardy due to human activities. Pollution, climate change, habitat destruction, hunting, and population growth are all threats to biodiversity. These human threats cause animal and plant species to become endangered. As an endangered species' population declines, it loses **genetic variation**. Genetic variation is the measure of the genetic differences there are within a population or species. Without genetic variation, a species is even more likely to become extinct. Conservation efforts are necessary to preserve biodiversity and genetic variation to protect endangered species and their habitats.

These tiger moths from the collection of the Smithsonian's National Museum of Natural History are all the same species but show genetic variation in colors and patterns.

Futures that Unite explores how we relate to one another, with the goal of tapping into our collective humanity. One way scientists are making collective decisions about the future is through conservation. The Cryo-Initiative equipment in FUTURES is used to collect and freeze biological materials, such as **gametes**, embryos, tissue, blood, and DNA, from threatened species. These biological materials can be used to breed, study, monitor, and ensure the genetic diversity of future animal populations. These biobanks can help preserve and save the planet's biodiversity and genetic variation, and may even eventually help bring animals back from extinction.

Smithsonian Cryo-Initiative biodiversity repositories preserve frozen biological material from threatened species.

Investigate

Time: 1 hour

Materials

For each group of 2 students

- 1 die
- Creature Mother Activity Sheet
- Creature Father Activity Sheet
- 2 Creature Template Activity Sheets
- Create a Creature Activity Sheet
- Creature Offspring Activity Sheet
- Crayons or colored pencils
- Scissors
- Glue

For each students

- Paper

Objectives

- Understand the fundamentals of genetic variation in the same species.
- Demonstrate how genes, through **homozygous** or **heterozygous** pairing, interact to express dominant or recessive traits.
- Demonstrate the difference between **genotype** and **phenotype** in an organism by identifying or providing various examples.

NGSS and Common Core Alignment

- NGSS Performance expectation: MS-LS3-2
- SEP: Developing and Using Models
- DCI: LS3.A Inheritance of traits
    - DCI: LS3.B Variation of Traits
    - CCC: Cause and effect
- Common Core Math Standard: 7.SP.C

Activity Overview

In this activity, students will create their own creature with physical traits that are determined genetically by chance, such as fur length, eye color, horn and wing shapes, teeth, and height. Students will discover the difference between genotype and phenotype and **dominant** and **recessive alleles** for each trait, and then predict inheritance in an offspring based on the traits of its two parents.

Procedure

1. Tell the students that this activity will be looking at biodiversity, genetic variation, and a program called the Smithsonian Cryo-Initiative.
2. Navigate to the Learning Lab collection at https://learninglab.si.edu/collections/futures-cryo-creature/ZqKQ5dECxUwm6FfR and project it for the class, or have students navigate to the collection on their individual devices.
3. Open the first website, US Fish and Wildlife Endangered Species. Search for endangered species in your state or click on Threatened and

Endangered Animals to see the list for the entire United States. Navigate through the list as a class or individually.

4. Ask students if they are surprised by any of the endangered animals and if there are animals they like that are on the list.

5. Navigate back to the Learning Lab collection and move to the second slide opening the Cryo-Initiative website.

6. As a class or individually, have students read through the information on the Cryo-Initiative. Review the glossary definitions of biodiversity and genetic variation with the students. Ask them to keep these two definitions in mind while working through the activity.

7. Lead a class discussion asking students why they think genetic diversity in animals is important. Explain that in the activity they will learn how genetics give animals physical characteristics, so they can better understand why scientists wish to preserve animals' biological materials through the Cryo-Initiative.

8. Divide the class into groups of two students. Give each pair one die, one Creature Mother Activity Sheet , one Creature Father Activity Sheet, two Creature Template Activity Sheets, one Create a Creature Activity Sheet, and one Creature Offspring Activity Sheet.

9. Review the glossary definitions for genotype, phenotype, **alleles**, homozygous, heterozygous, dominant alleles, and recessive alleles with students. Write them on the board or project the glossary so students can refer back to the definitions.

10. Tell the students that they will be creating their own creatures to better understand genetic variation. Ask students to determine which student will fill in the Creature Mother Activity Sheet and which student will fill in the Creature Father Activity Sheet.

11. Tell students that each allele will be determined by the roll of a die. Odd numbers will be dominant alleles. Even numbers will be recessive alleles.

12. Explain that for each genetic trait, each partner rolls the die twice for their assigned parent to get two alleles. Work through the first trait on the Creature Mother Activity Sheet, fur length, with the students, as an example of how to record their data. Answer any questions.

13. For each trait, ask students to use the alleles decided by the roll of the die to determine the genotype, whether the alleles are homozygous recessive, heterozygous, or homozygous dominant, and finally the phenotype.
14. When the phenotype for each trait has been determined for both the Creature Mother and Creature Father, instruct students to find the traits they've assigned to the Creature Mother on the Creature Template Activity Sheet. They should color and cut out the creature pieces and glue them to the Create a Creature Activity Sheet, in the box labeled "Mother." Then they should do the same for the Creature Father, using a fresh Creature Template Activity Sheet, if necessary.
15. Instruct the students that now they will use their Mother and Father charts to create a chart for the two creatures' offspring. Have the students determine the alleles for the Creature Offspring from the parents' charts, with Allele 1 coming from the Creature Mother and Allele 2 coming from the Creature Father.
16. Then have them determine the genotype, whether the alleles are homozygous recessive, heterozygous, or homozygous dominant, and finally the phenotype for the offspring.
17. When the phenotype for each trait has been determined for the Creature Offspring, instruct students to draw and color the creature in the box labeled "Offspring" on the Create a Creature Activity Sheet.

Share

Procedure

1. Now that students understand more about biodiversity and genetic variation, navigate to the Learning Lab collection Black-Footed Ferret Conservation Stories sections at https://learninglab.si.edu/collections/futures-cryo-creature/ZqKQ5dECxUwm6FfR. Have students individually write short answers to these questions:

- How can we use human technology to preserve biodiversity and save endangered species?
- What do I envision for the future of biodiversity?
- What is one animal species alive or extinct that I want in a biobank to maintain or restore the wild population?

Creature Mother Activity Sheet

Creature 1: Mother							
Trait	Dominant Allele	Recessive Allele	Allele 1	Allele 2	Genotype	Homozygous Recessive, Heterozygous, Homozygous Dominant	Phenotype
Fur Length	Long (L)	Short (l)					
Fur Color	Green (G)	Blue (g)					
Eye Color	Purple (P)	Blue (p)					
Horn Shape	Curved (C)	Straight (c)					
Wing Shape	Dragonfly (D)	Butterfly (d)					
Wing Color	Purple (R)	Red (r)					
Feet	Not webbed (W)	Webbed (w)					
Height	Tall (H)	Short (h)					
Teeth	Pointed (T)	Blunt (t)					

Creature Father Activity Sheet

Creature 2: Father							
Trait	Dominant Allele	Recessive Allele	Allele 1	Allele 2	Genotype	Homozygous Recessive, Heterozygous, Homozygous Dominant	Phenotype
Fur Length	Long (L)	Short (l)					
Fur Color	Green (G)	Blue (g)					
Eye Color	Purple (P)	Blue (p)					
Horn Shape	Curved (C)	Straight (c)					
Wing Shape	Dragonfly (D)	Butterfly (d)					
Wing Color	Purple (R)	Red (r)					
Feet	Not webbed (W)	Webbed (w)					
Height	Tall (H)	Short (h)					
Teeth	Pointed (T)	Blunt (t)					

Creature Offspring Activity Sheet

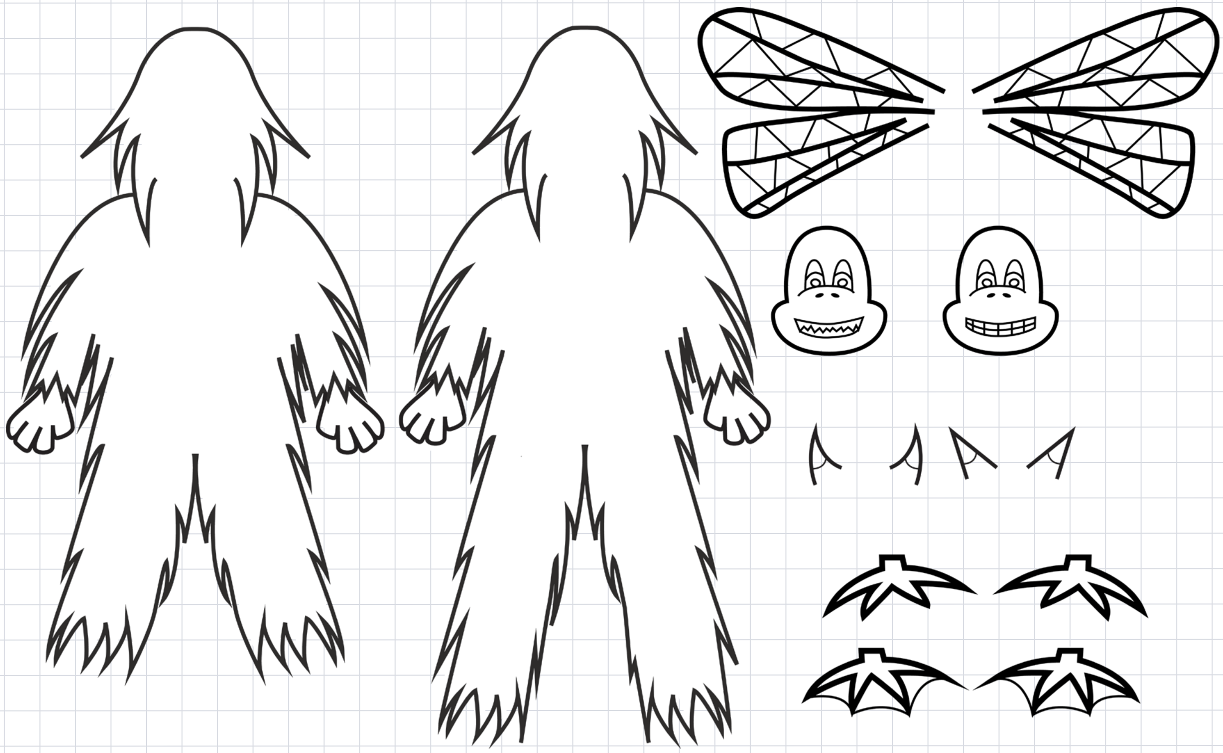
Creature 3: Offspring							
Trait	Dominant Allele	Recessive Allele	Allele 1	Allele 2	Genotype	Homozygous Recessive, Heterozygous, Homozygous Dominant	Phenotype
Fur Length	Long (L)	Short (l)					
Fur Color	Green (G)	Blue (g)					
Eye Color	Purple (P)	Blue (p)					
Horn Shape	Curved (C)	Straight (c)					
Wing Shape	Dragonfly (D)	Butterfly (d)					
Wing Color	Purple (R)	Red (r)					
Feet	Not webbed (W)	Webbed (w)					
Height	Tall (H)	Short (h)					
Teeth	Pointed (T)	Blunt (t)					

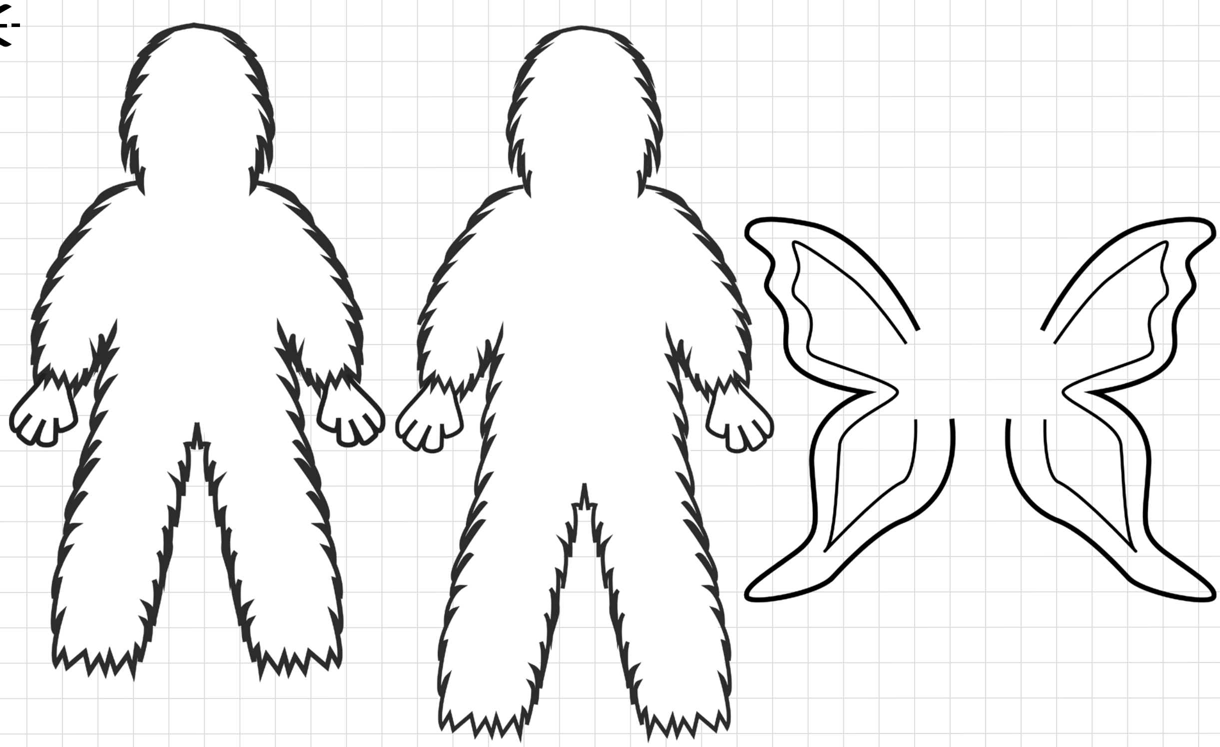
Create a Creature Activity Sheet

Mother	Father

Offspring

Creature Template Activity Sheet





Glossary

Alleles: The different forms a gene may have for a trait

Biodegradable: Something that can be decomposed by bacteria or other living organisms

Biodiversity: The variety of life in the world or in a particular habitat or ecosystem

Climate change: A long-term change in average weather patterns that has come to define Earth's local, regional, and global climates

Dominant alleles: The form of a gene that, when included in the genotype, is expressed in the phenotype

Ecosystem: A biological community of interacting living and nonliving things in an area

Gamete: A reproductive cell that contains half the genetic material needed to form a complete organism

Genetic variation: The measure of the genetic differences there are within a population or species

Genotype: The genetic makeup of an organism

Heterozygous: When the two alleles that make up the genotype are different

Homozygous: When the two alleles that make up the genotype are the same

Natural material: Any product or physical matter that comes from plants or animals, or that is extracted from the ground

Phenotype: The physical appearance; the traits expressed from an interaction of the genotype with the environment

Recessive alleles: The form of a gene that is expressed in the phenotype only when both alleles of the genotype are recessive

Sustainability: The ability to maintain natural resources and to keep an ecological balance

Synthetic material: A compound made artificially by chemical reactions

Unsustainable: Something that is not able to be maintained at the current rate or level

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Smithsonian Science Education Center: Development Staff

SSEC Director

Dr. Carol O'Donnell

Division Director, Curriculum, Digital Media, and Communications

Laurie Rosatone

Assistant Division Director, Digital Media & Communications

Ashley Deese

Interactive Developer

Reuben Brenner Adams

Graphic Designer

Sofia Elian

Marketing & Communications Specialist

Cara Hackett

Lead Product Specialist

Hannah Osborn

Lead Digital Producer

Ryan Seymour

Arts + Industries Building: Development Staff

Director

Rachel Goslins

Director of Advancement

Laith Alnouri

Director of Education + Visitor Engagement

Ashley Meadows

Curator of Special Projects + Programming + Social Justice

Monica O. Montgomery

Manager of Operations

Melissa Rasowski

Share your ideas with your family, class, community, or on social media with #TheFUTURES.

@smithsonianaib
@smithsonianscie

Teacher Toolkit for Sustainable FUTURES was created in partnership with the Arts + Industries Building and the Smithsonian Science Education Center.

Please visit aib.si.edu for more information about FUTURES. Please visit ScienceEducation.si.edu/futures-toolkit for digital r esources that enhance the toolkit lessons.

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