

# Evaluate the Help-Harm Balance of Sunscreen to People and Our Marine Environment

## High School Guam STEM Design Challenge

**Anchor Question:** How is the sun both beneficial and harmful? What risks and benefits do using different sunscreens create for people, our coral reefs, and other marine life?

### Overview

#### **Guam Connection**

Tourism is a major industry on Guam, and residents of Guam spend time in and near the ocean. Among the chemicals raising concerns in health and beauty products including sunscreens, are oxybenzone, octinoxate, octocrylene and some parabens. These chemicals make coral more susceptible to bleaching and could stunt the growth of baby corals. Sunscreen pollution can affect reefs up to 5km away. Experts say these chemicals can be found in roughly half of all sunscreen brands. To protect the reefs many islands in the Pacific now require reef safe sunscreens be used on their islands (I.e., Palau, Bora Bora, etc.) Even if you are miles away, chemicals wash off your body in the shower/bath will eventually find their way to the ocean. Help coral reefs everywhere by avoiding all body care products with oxybenzone and octinoxate.

#### **Engineering Design Challenge**

Residents and tourists use sunscreen year-round on Guam's semi-tropical environment, which is surrounded by protective, diverse coral reefs. This marine environment is being harmed by the chemicals in sunscreens that are most commonly available. Evaluate which of the locally available sunscreens are the most effective to prevent sunburns but are not damaging to the local marine environments. Create a solution in the form of a technology-generated media campaign to encourage tourists and residents to use reef-safe sunscreens.

#### **NGSS Performance Expectation**

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural [eco]systems.

HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-ETS1.3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs.

#### **STEM Concepts (NGSS Disciplinary Core Ideas)**

PS4-4: When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

ESS3.C: Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude [prevent from happening] ecosystem degradation.

ETS1.B: Developing Possible Solutions: When evaluating solutions, consider a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

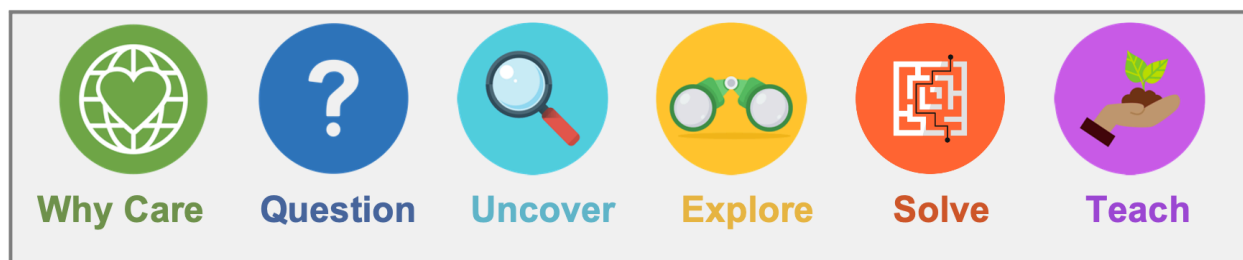
#### **Time: Estimated Number of Classes**

3-4 classes (45-minute class)

#### **Materials for the Design Challenge**

Small jars, multiple sunscreens found on island, UV camera, UV detecting beads, Sunprint paper

## The Q-U-E-S-T Experience



**Why Care?** What is the problem, anchor question, and design challenge? How is this relevant and interesting to us and where we live?

**Question** Begin by asking QUESTIONS about the problem and ways to solve it. Figure out what you already know, and brainstorm what you could do.

**Uncover** Learn the science ideas needed to understand the problem and design a project to solve the problem.

**Explore** Apply what you've learned in Uncover to EXPLORE the problem in your community and consider project ideas to solve the problem.

**Solve** Use the engineering design process to design and do a project that helps SOLVE the problem.

**Teach** Share your project with others to help others understand the problem and how your project helped solve it.



### **Why Care?**

*What is the problem, anchor question, and design challenge? How is this relevant and interesting to us and where we live?*

### **Introduce the Quest**

1. **Post and read the anchor question:** How is the sun both beneficial and harmful? What risks and benefits do using different sunscreens create for people, our coral reefs, and other marine life?
2. **Read, describe, and post the design challenge:** Symposia in Hawaii are being held to discuss the challenges facing coral reefs. Sunscreen and other personal care product ingredients were hot topics. Of particular concern to scientists was oxybenzone, a chemical used in sunscreens to protect our skin from damaging UV light. Oxybenzone is bad news for corals. Evaluate which of the locally available sunscreens are the most effective to prevent sunburns but are not damaging to the local marine environments. Create a solution in the form of a technology-generated media campaign to encourage tourists and residents to use reef-safe sunscreens.
3. **Share and talk about the Driving Question for why we should care:** Why should I care about using reef-safe sunscreens?

4. **Do this:**

- a. Discuss with students. Residents and tourists use sunscreen year-round across Guam's semi-tropical environment, which is surrounded by protective, biologically diverse coral reefs. This marine environment is being harmed by the chemicals in sunscreens that are most commonly available. What can we do to help solve this problem as individuals and as a community?
- b. Ask this question: How can we reduce the impacts of sunscreen on coral reefs?
- c. Read about the ad campaign [Maui Reefs: Preventing Sunscreen Pollution](#) that alerts residents and tourists about the dangers of harmful sunscreen chemicals. How does this relate to Guam?
  - i. Watch the YouTube video [Sustainable Sunscreen: Making SPF Reef Safe](#). Think and talk about how these sunscreens differ from most readily available sunscreens.

**Guam-STEM Design Notebook for students ([FOLDER with pdf and editable pages](#))**

Write or draw your "why I care" and why others on Guam care.



**Question**

*Begin by asking QUESTIONS about the problem and ways to solve it. Figure out what you already know, and brainstorm what you could do.*

**Ask Questions**

1. **Create a KND Chart (Know, Need to know, Do)** with the three driving questions below. Save the questions and responses to look at during the QUEST. Ask students to write them on chart paper, butcher paper, in student design notebooks, or use a digital organization chart, like Jamboard. KND Questions:
  - a. What do we **KNOW** already about sunscreen, sunlight, coral reefs, and the effects of chemicals on the marine environment? (Electromagnetic spectrum, UV radiation, coral reef ecosystems)
  - b. What do we **NEED TO KNOW** to evaluate different sunscreens' effectiveness and their impact on coral reef ecosystems?
    - i. Here are a few examples students might ask: What are the harmful chemicals in sunscreens?
    - ii. How does one kind of sunscreen differ from another?
    - iii. How does the SPF number affect effectiveness? Is higher always better? What about for small kids?
  - c. What could we **DO** to learn about how sunscreens work and their impact on coral reefs? What are some ideas of what we could DO to test sunscreen effectiveness, compare brands, and investigate reef-safe sunscreens?
2. **Gather responses from students.** Have students think and write responses: First, silently and individually. Then, in small groups. And finally, with the full class. The result is a class KND chart to refer to, add to, and reorganize throughout the QUEST. Students could also sort the responses that are similar. This information will help guide the UNCOVER and EXPLORE.

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Write KND lists. Organize the questions (Need to Know) from class. Record the categories, or themes, of the questions and ones you are most interested in.



## Uncover

Learn the science ideas needed to understand the problem and design a project to solve the problem.

Remember that our goal is to design or refine a solution to a complex real-world problem, based on scientific knowledge, your student-generated sources of evidence, prioritized criteria and tradeoff considerations. Begin by answering the driving questions to learn about the science ideas you need to understand.

### Uncover Key Ideas

1. **Share the Driving Question:** How does sunlight harm or help us?
  - a. More questions: What are the risks and benefits of spending time in sunlight? What are the dangerous types of UV radiation on human skin?
  - b. Use the following lessons to help understand the science behind the issue.
    - i. [The Pros and Cons of Sunscreen](#)
    - ii. Effectiveness of sunscreens: links and more about sunlight in [slides](#) in resource folder (select only the slides that you need at this point)
    - iii. Record what you did and learned.
2. **Share the Driving Question:** How effective are different sunscreens at blocking the sun's harmful UV rays?
  - a. More questions: What are the differences among the sunscreens that are commonly purchased and/or brought to the island? How can you find out? How are water-based sunscreens different from oil-based sunscreens?
  - b. Read the following article and watch the video: [The Science of Sunscreen](#)
3. **Share the Driving Question:** How do different sunscreen products interact with the marine environment?
  - a. Read the following article and watch the embedded videos.
    - i. [Skincare Sunscreen and Coral Reefs](#)
    - ii. [Sunscreen pollution accelerating demise of coral reefs](#)

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Write the driving question and summarize what you did and learned. (blank page)

### Students will understand these NGSS Disciplinary Core Ideas:

PS4-4: When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

ESS3.C: Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude [prevent from happening] ecosystem degradation.

ETS1.B: Developing Possible Solutions: When evaluating solutions, consider a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.



## Explore

Apply what you've learned in Uncover to EXPLORE the problem in your community and consider project ideas to solve the problem.

### Apply Your Learning

1. **Share the Driving Question with students:** How can we apply what we learned in UNCOVER to understand the problems posed by sunscreens that are harming the marine environments in our community and to come up with project ideas to help solve the problem?
2. **Revisit the KND lists** you wrote at the beginning of your Quest. Add and edit them to include new understandings and experiences from UNCOVER.
  - a. KNOW - What have you confirmed as accurate? Correct any inaccurate information.
  - b. NEED to know - Mark any questions that you have answered, and ones you still need and want to answer. Add new questions.
  - c. DO - Add any new project ideas you could do to help solve the problem.
3. **Return to the anchor question:** How is the sun both beneficial and harmful? What risks and benefits do using different sunscreens create for people, our coral reefs, and other marine life?
4. **Learn about reef-safe sunscreens.** Determine how they work and how they differ from most common sunscreens.
5. **Research (visit stores, go online) sunscreens that are available on Guam.** Determine their ingredients to answer these questions:
  - a. How can we test reef-safe and other sunscreens to determine their effectiveness at blocking UV (ultraviolet) rays. Use UV-sensitive beads or other materials. Evaluate which of the locally available sunscreens are the most effective to prevent people from getting sunburned but not damaging to the local and marine environments. Analyze your findings and share with other teams. To do your tests you can get a piece of sun-sensitive paper and see what happens when it is exposed to UV light. You can also use UV sensitive beads. There are now many products that change colors when they absorb UV radiation [t-shirts, nail polish, etc.] Be creative! [UV Sensitive Beads](#)
  - b. How can we test which sunscreens are water resistant? [TEST water resistant sunscreen](#)
  - c. Find readings, infographics, videos to compare all the options for sunscreens on Guam. Small groups could be read one resource, shared with other groups in a jigsaw, and record findings.
    - i. [Protect yourself, Protect your reef](#), NPS
    - ii. [Reef Toxic Sunscreen Banned in Palau](#), PNC Guam
    - iii. [Tourism's Effect on Guam Reefs](#), Guampedia
6. **Read and talk about the design challenge:** Residents and tourists use sunscreen year-round on Guam's semi-tropical environment, which is surrounded by protective, diverse coral reefs. This marine

environment is being harmed by the chemicals in sunscreens that are most commonly available. Evaluate which of the locally available sunscreens are the most effective to prevent sunburns but are not damaging to the local marine environments. Create a solution in the form of a technology-generated media campaign to encourage tourists and residents to use reef-safe sunscreens. (Examples: social media post, infographic, signs for stores or hotels, app, video public service announcements, interviews on local news outlets, write and record a song, etc.)

**Guam-STEM Design Notebook for students ([FOLDER with pdf and editable pages](#))**

- Design Challenge Map- Complete as much as you can. Then add to and edit it throughout SOLVE.
- Design Requirements and Limitations (criteria and constraints)



## Solve

*Use the engineering design process to design and do a project that helps SOLVE the problem.*

### Design & Do Your Project!

1. **Project Design:** How can I create and test a design that is most effective at helping solve the problem? (Examples: social media post, infographic, signs for stores or hotels, app, video public service announcements, interviews on local news outlets, write and record a song, etc.)
2. **Do this:** Follow the [Engineering design process \(Poster\)](#) steps to determine the most effective design to solve the problem.
  - a. Select the design idea you want to create.
    - i. Decide what you want your technology-generated media campaign to look like. Create the design idea.
    - ii. Determine any constraints.
    - iii. Get the materials you need to create your media public service announcement.
    - iv. Create your informative display (see the examples provided).
  - b. Test your media campaign material to see if it will inform students and your target audience about the issues related to safe sunscreens.
    - i. How well did it work and what could you do to make it work better?
    - ii. Students can revise their technology-based media campaign on their proposed solution and answer these questions.
      1. What worked well?
      2. What did not work well? Why do I think it did not work well?
      3. How could I improve my media campaign design solution?
  - c. Students modify their media campaign or design a new solution. Then test it and compare how well it worked compared to their first approach. Encourage them to make 2-3 different versions and be able to explain why one solution works better than another. Remember your constraints and the impact on your design solution.

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- Edit and complete the Design Challenge Map.
- Edit and complete the Design Requirements and Limitations (criteria and constraints)
- Action Plan: List steps to complete the project, and who will do what.
- Team Self-Review: Review your project design to make sure it is focused on the design challenge, anchor question, and Guam.
- Gathering Feedback from Others: Get input from others to help strengthen your project.
- Claim-Evidence-Reasoning (CER): Give evidence for the most effective project design.

### **Students will understand these NGSS Disciplinary Core Ideas:**

*ETS1.B: Developing Possible Solutions: When evaluating solutions, consider a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.*



### **Teach**

*Share your project with others to help others understand the problem and how your project helped solve it.*

### **Share & Reflect on What You Learned**

1. **Return to the anchor question:** How is the sun both beneficial and harmful? What risks and benefits do using different sunscreens create for people, our coral reefs, and other marine life?
2. **Prepare and creatively share** their project and who it helped solve the problem.
  - a. Who's your audience? Who will benefit from hearing about and seeing your project?
  - b. How will you share this information?
  - c. What do you want them to know and understand about the problem posed by sunscreens that damage the marine environment, how you collected data on the effectiveness of sunscreens, the benefits and dangers of UV radiation and how your project would help solve the problem and lessen the harmful impacts?
  - d. When and where will you share?
3. **Student reflection:** After teaching others, students can complete a reflection about their Design Challenge. Here is one option: 4-3-2-1: Looking back, planning forward. Respond to:
  - a. FOUR of the most important things I learned doing this design challenge.
  - b. THREE of the most important things I learned about myself doing this design challenge.
  - c. TWO things I will do differently in my next problem-solving experience.
  - d. ONE thing I now want to learn more about.

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