NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

What's for Dinner?

A Fish Mouth Challenge

Grades 9-12

Teacher Guide

Seaworthy STEM™ in a Box Series

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Teacher Guide for 9-12

#SEAWORTHYSTEM®

Seaworthy STEM™ in a Box Educator Kit description:

Seaworthy STEM™ in a Box activities are a Navy initiative to provide enhanced Naval-relevant, standards aligned, hands-on activities to K-12 teachers and students. Components of this program include, curated sets of classroom activities that aim to build deep conceptual understanding in Naval-relevant content areas. The kits also includes comprehensive lesson plans, material lists, scientific background information, STEM related literacy books, and student activity sheets. The Seaworthy STEM™ in a Box program is designed to support teachers as they select content, acquire materials, and implement more hands-on STEM activities in their classrooms. Increasing student access to hands-on STEM activities, also increases awareness of STEM career paths, engage students in STEM, and support development of student's abilities in STEM content.

The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

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Introduction

Welcome to an innovative curriculum designed to engage students in the world of engineering, problem-solving, and creative thinking. This curriculum is structured around three fundamental components, each carefully crafted to provide students with a comprehensive learning experience. In this curriculum, each lesson is divided into three parts: Journal Entry, Part 1, and Part 2.

Parts of Each Lesson

Journal Entry
The first part of every lesson serves as a bridge between what students already know and what they are about to learn. The Journal Entry is an opportunity for students to reflect on their prior knowledge and experiences related to the topic. These questions will stimulate critical thinking and prime students for the exploration of new concepts. The teacher can mold these questions into a format that best fits their class. This entries can be done in the student workbook, a separate journal notebook or another location determined by the educator.

Part 1: Introduction & Research
Following the Journal Entry, Part 1 of each lesson is dedicated to research and in-depth exploration. The students will delve into the subject matter, investigate key concepts, and gather valuable information. This phase is essential in providing the foundation for the Engineering Design Challenge, ensuring that students have the necessary background knowledge and skills to approach real-world problems effectively.

Part 2: Engineering Design Challenge
The culmination of each lesson is the Engineering Design Challenge. This is where students put their newfound knowledge and research skills to the test. They will work through the engineering design process, applying their problem-solving abilities to develop practical solutions. The challenges are crafted to mimic real-world scenarios, allowing students to experience the fulfillment of creatively designing their own products.

Here We Go!

By the end of this curriculum, students will have the tools and confidence to address real-world challenges in a systematic way. This curriculum is designed to provide the basics and help organize a young engineers thought patterns. Teaching students how to map out their thinking is essential in the development of world changing solutions. We are excited to embark on this educational journey with you! Let's get ready to journal, research, and create as we embark on a #SeaWorthySTEM learning adventure!

Table of Contents

Lesson Title:

What's for Dinner?

A Fish Mouth Challenge

Time:

Average learning time is 4-5, 50 minute class periods

Student Objectives:

The students will be able to explain that variation in an environment is important for the survival of a species. The students will determine why species have specialized body structures depending on their environment.

Lesson Overview:

The students will compare and contrast the mouths of several species of fish. They will then explore connections between features of a fish's mouth and its diet. An included extension activity provides examples of how the United States Navy uses biomimicry in its designs. The students will then utilize the engineering design process to construct a functional scale model prototype of a submersible rescue vehicle that is camouflaged like a marine organism and will be able to use its mouth to retrieve a Lego diver.

Next Gen Science Standards (NGSS):

HS-LS4-2
Biological Evolution: Unity and Diversity
Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4-4
Biological Evolution: Unity and Diversity
Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

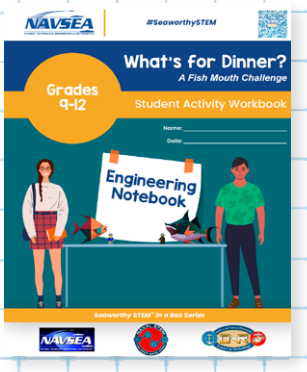
Notes

HS-LS4-5
Biological Evolution: Unity and Diversity
Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

HS-ETS1-2
Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Materials and Equipment List

- ☑ Computer w/ attached projector
- ☑ Student Worksheets & Writing Utensil *(Google Docs is also an option)*
- ☑ A variety of materials to build a fish mouth *(Possible materials may include, but are not limited to: Spoons, forks, rubber bands, balloons, pipe cleaners, paper clips, pencils, tacks, cylinders, wooden skewers, cardboard, Legos, glue, & duct tape)*
- ☑ Teacher access to the internet *(YouTube needs to be available)*
- ☑ Student access to an internet compatible device



Student Activity Sheets/Handouts:

Student Activity Worksheet:
What's For DInner? A Fish Mouth Challenge

Technology Tools:

Teacher access to the internet (YouTube)
Student access to an internet compatible device

Part I: Procedure

1 Pre-Assessment Activity:

The student journal response can be used as a pre-assessment for this unit. This journal entry can be included in the student journal or in a separate notebook. Below are sample journal prompts, but feel free to incorporate your own.

Sample Journal Prompts:

1. Are structures on animals important for survival? Why or Why not? Give examples?
2. What human innovations have been inspired by animal adaptations?

2 Pre-Activity:

To be completed in on a sheet of paper or in the student's science journal.

Tell the students to "Think of a fish's mouth" then answer the following questions:

1. What are some characteristics you have noticed?
2. Are all fish mouths the same?
3. If not, why do you think they are different?
4. How could environmental changes impact an organism's chances of survival and reproduction?
5. Draw at least 2 different fish mouths in your journal.

3 Hook:

Show this video of fish eating:
"About Mouths of Fish and Feeding" (8:46)
https://www.youtube.com/watch?v=2YODWSF-tko

YouTube:

4 Fish Research Sheets:

Have the students complete the 5 fish research sheets found within the "Teacher Resource Section" of this unit.
**Some teachers will have the students do this part of the assignment digitally using Google Docs.*

5 Student Biology Discussion:

After the students complete their research, use the information within the "Student Biology Background" to review with the students.

6 Engineering Design Challenge:

Discuss biomimicry, share Navy examples and work through engineering design extension: "Building the Perfect Fish Mouth."

Part 2: Engineering Design Challenge

Background Information:

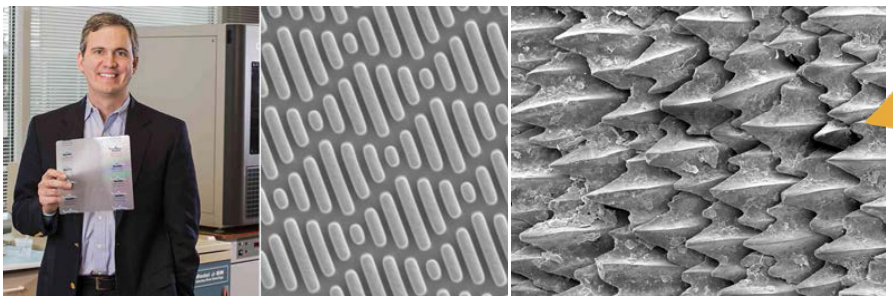
Biomimicry is the process of creating sustainable products and developing systems inspired by things in nature. The word biomimicry is made up of two separate words, i.e., *bio* and *mimicry*. Bio means living things, and mimicry implies imitation. This implies that biomimicry is the process of imitating life. The process of biomimicry can be used as a great combat technique to deal with the problems created due to urbanization and modernization. Examples include:

- The study of beavers to create wet suits.
- The study of termite dens to design energy efficient high rise office buildings.
- The study of plant burrs to inspire the engineering of Velcro.
- The study of birds and how they not only manipulate their wings during flight, but also fly in formation to conserve energy during flight.

Navy Examples of Biomimicry:

Boston Engineering is developing the GhostSwimmer™ Autonomous Undersea Vehicles (AUV) based on the design of comparably sized biological systems (fish and cetaceans) for inspiration. Data suggests that oceanic biological systems achieve high propulsive efficiencies (to 87%), and have extraordinary abilities to maneuver at both high and low speeds, far in advance of any conventional man-made vehicle. They do so using a flexible, streamlined body propelled by a single oscillating tail foil, an appropriately placed set of pectoral (and auxiliary) fins and a finely tuned muscular/sensory/control system.

The U.S. Navy has also developed a material, known as Sharklet, based on this skin pattern to help inhibit marine growth on ships. Sharklet draws inspiration from the shape and pattern of the dermal denticles of sharkskin. Sharks are resistant to fouling organisms in the water including algae and barnacles.



Sharklet

The Engineering Design Challenge:

The Navy has tasked your design team with creating an unmanned submersible vehicle that is capable of rescuing stranded divers from the water. Your vessel must be able to blend into its surroundings while at the same time being able to use its mouth to retrieve and store the diver which will be represented by a Lego person.

Procedure:

Pre-Activity: Students will fill out a Team Dynamics page to review expectations and goals of the challenge.

1 What is the Problem?

- Have the students discuss the basic scientific principles associated with the lab: stability and buoyancy.
- Introduce the engineering challenge:
  - ***Create an unmanned submersible vehicle that can rescue stranded divers from the water***
  - Form small teams and distribute the materials. Note: If allowing students to choose materials at random, create a materials home-base (a large box or storage container) designated for hand-selected materials.
  - Have the students formulate a problem (in question form) from the scenario provided.

2 What are the Criteria and Constraints?

- Have the students list out the criteria and constraints for the lab.
- Constraints: Provide your students with a list of constraints for the engineering design challenge.
- Discuss budget constraints (a limited number of materials per team).
- Have the students fill out the budget form for their design.

Possible ideas are listed below:

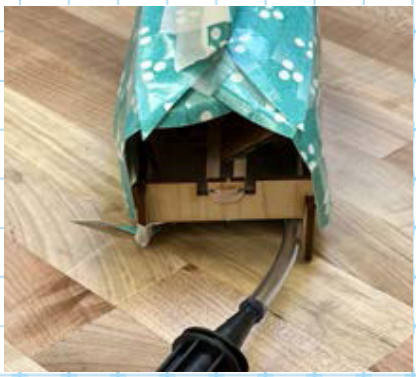
- You will have (pre-determined number) of class periods to design, build and test your project.
- Your fish mouth must be modeled on an

actual species of fish.

- Your design must be a complex machine (It must contain 2 or more simple machines)
- The use of hydraulics (by using syringes) can count as one of the machines.
- Your fish must be able to eat at least one type of prey.
- Your hands cannot directly touch your fish mouth during the eating phase of the design challenge.

3 How can we Brainstorm and construct the Prototype?

- Have the student brainstorm multiple designs for their prototype.
- Students will choose one design, justify their choice in the writing section and build their models according to their designs.
- Emphasize teamwork, creativity, and adherence to budget.



4 How can we Test and Data Collection?

- Each team tests their prototype by:
  A. Placing it in a container of water.
  B. Timing the fish "feeding" period. Use a consistent timeframe for each trial.
  C. Record the number of prey that fish model consumes successfully.
  D. Note: Teacher can modify the requirements for testing and data collection to fit the need of the class.

5 What are our Findings? Data Analysis and Reflection

- Team present their findings by creating a data chart, graph and reflection statement to discuss the findings of their prototype.

- Teams discuss what worked and what didn't in their boat design.
- Reflect on the engineering design process by answering the following questions:
    A. Does my prototype meet the requirements of the design challenge?
    B. Can I improve the design from its original specifications?
    C. How can I reduce the cost of my final prototype without sacrificing quality?

6 **Let's Improve it! Class Discussion, Team Redesign Conclusion**

- Discuss the most successful boat designs and strategies.
- Relate the activity to real-world applications in naval engineering and ship design.

7 **Peer Evaluation of Teamwork**

- Students will be providing feedback of teammates and collaboration.

Teacher Background Information / Notes:

Bodies of water actually contain multiple distinct layers (light, pH, oxygen levels, salinity, etc). While some fish do range throughout the multiple layers of water, most fish spend the vast majority of their lives living in one distinct zone. This makes sense as most species have adaptations that are better suited for one environment as compared to the other. One example of this type of specialization is that many species of fish have mouths oriented in a manner that help them consume readily available organisms: An upward turned mouth likely means the fish primarily eats things above it in the water column. A forward facing mouth likely means the fish primarily eats things in front of it in the water column. A downward facing mouth likely means that the fish primarily eats things below it in the water column.

Additional questions that may help prompt classroom discussion:

- In the wild, which type of fish mouth is most common? Write a couple sentences that support your claim.
- Some fish have sharp teeth while others have small sandpaper like structures. What do you think is a primary food source for fish with sharp teeth?
- How can an organism's teeth provide a clue if an organism is a carnivore, omnivore or a herbivore? What type(s) of teeth do humans possess? What do these teeth tell you about the type of food that our species consumes?
- Many fish that eat on or near the bottom have dangling structures at the corners of their mouths called barbels (Include a pic of a catfish). How do these fleshy filaments help the animal find prey?
- Most species of fish have drastically changed over time. However, several shark species have changed very little over the past 100 million years. Why do you believe that most sharks have

remained very similar to their ancient ancestors?

- If you were a fish that consumed insects, what kind of mouth would you likely possess? Explain your answer.
- If you were a fish that lived in a muddy water environment, what kind of mouth do you believe would be the most beneficial to your survival? In a couple of sentences, explain your answer.
- If you were a fish that ate other fish, what kind of mouth do you believe would be the most beneficial to your survival. In a couple of sentences, explain your answer.

Teacher Preparation:

Reading through the background information contained within this lesson will provide the teacher with the minimal amount of subject familiarity to work through this lesson with the class. Previewing as well as "bookmarking" exemplar websites for student use would be helpful. Copies should be made of the pages within the teacher resources for each student.

Common Misconceptions/Preconceptions:

Many students may assume that all species of fish roam throughout the water column whereas most fish actually spend the vast majority of their lives living in one distinct zone. In this specific area, their species has adapted over time to become specialized so it has distinct advantages that help them eat which gives them energy to reproduce.

The materials in the video are different from the ones I've suggested, but you can improvise depending on what you have readily available. Be cautious is you include lamp oil or alcohol as they are flammable and need to be carefully handled in the classroom setting.

Vocabulary Terms:

- **Adaptation:** any alteration in the structure or function of an organism or any of its parts that results from natural selection and by which the organism becomes better fitted to survive and multiply in its environment. A form or structure modified to fit a changed environment.
- **Biomimicry:** The design and production of materials, structures, and systems that are modeled on biological entities and processes.
- **Characteristic:** A distinctive mark, feature, attribute, or property of an individual or thing.
- **Prototype:** A first, typical or preliminary model of something, especially a machine, from which other forms are developed or copied
- **Species:** A group of organisms that can reproduce with one another in nature and produce fertile offspring. A scientific system group of organisms with similar biological characteristics.
- **Water Column:** a vertical section of water from the surface to the bottom of the sea, a lake, a river, etc.

STEM Related Careers:

- Marine Biologist
- Oceanographer
- Mechanical Engineer


Notes

The Seaworthy STEM™ in a Box curricula was developed through collaborative efforts of a team of individuals at the Naval Surface Warfare Center Carderock Division and Albert Einstein Distinguished Educator Fellows via an inter-agency agreement with the U.S. Department of Energy for the Albert Einstein Distinguished Educator Fellowship (AEF) Program. We are grateful to the following Content Specialists who contributed their knowledge and expertise by researching and writing on selected topics: Suzanne Otto, Stephanie Klixbull, Thomas Jenkins and Melissa Thompson. We'd also like to acknowledge the contributions of AEF participant Ms. Deborah Reynolds, the inaugural AEF Educator at Carderock that helped inspire the design of Seaworthy STEM™ in a Box content. Special thanks to Albert Einstein Fellow Melissa Thompson, for the creation of a collaborative high school engineering curriculum and supplemental additions to the early grade bands; career portfolios, workforce trading cards, and in-house short story publications. Gratitude to Carderock Outreach Specialist Ashlee Floyd, STEM Program Manager, Charlotte George, and Media Specialist Kristin Behrle for the creation and support of this naval endeavor that showcases the diversity of NAVSEA Sites.

It is the goal of the Seaworthy STEM™ Curriculum to embrace NAVSEA technologies from sites nationwide to empower the youth of our nation to purse STEM-centric career pathways. The views and opinions of the Content Specialists expressed herein do not necessarily state or reflect those of the AEF Program, the U.S. Department of Energy, or the U.S. Government. Reference herein to any specific commercial product, process, or service by trade name, trademark, service mark, manufacturer, or otherwise does not constitute or imply endorsement, recommendation, or favoring by the AEF Program, the U.S. Department of Energy, or the U.S. Government.

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