SUCK IT UP! | EDUCATOR

Next Generation Science Standards |
MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success
MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Common Core Standards |
CCSS.ELA-LITERACY.WHST.6-8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

S T E M

Supplement Video |
https://www.youtube.com/watch?v=c6i2nh_c7Cg
https://vimeo.com/165288756 (password: exploration)
Pacing | 1-2 class periods (45 minutes each)
Background Needed | Basic understanding of engineering and design principles (http://nautl.us/2d7PDte), pressure, and Brownian motion
Assessment | STEM Project & Task rubric provided
Materials/Resources |

- Disposable nitrile or lab gloves
- Duct tape
- Rubber bands
- Straws
- Empty 16.9 or 20 oz. water bottles with wide end removed *(Tip: Use shears to remove the bottom below the label)*

- Tall (20 oz.) clear plastic beverage cups with small hole cut through the center of the bottom (*Tip: use a small drill bit to make the initial passageway, then increase bit diameter to make a larger opening; you can make various-sized openings for students to choose from)*
- Clear vinyl tubing - assorted sizes (suggested diameters: 3/4" or 1")
- Mesh material like nylon pantyhose of assorted sizes
- Small objects such as paper hole punchouts, small rubber bands, or pipe cleaners cut into small pieces
- 3 small clear bins per group filled halfway with water, labeled 1, 2, and 3
- Ground black pepper or pencil shavings

Overview

In this inquiry based module students will have the opportunity to design and build their own suction sampling devices and test those devices to collect various sized materials from a water environment. Students will complete two challenge activities, collect data and make connections between their devices and real oceanographic tools. Students will learn how changes in pressure allow some tools to work.

Objectives & Learning Outcomes

- Students will design a tool that can utilize changes in pressure to collect various materials from a tank of water.
- Students will understand how changes in pressure can allow physical, biological, and mechanical processes to occur.
- Students will learn about oceanographic tools, engineering, and sampling techniques.
- Students will describe the importance of sampling in the deep sea.

Set The Stage!

Get students thinking about how pressure affects the movement of molecules by setting up the following demonstration:

1. Place a candle on a flat glass, ceramic or metal plate that's wide enough to pour 1/2 - 3/4 cup water around the candle. Add food coloring to make the water be more visible.
2. Light the candle and place a small glass jar upside down over the candle. Be sure the entire edge of the jar is underwater.
3. Have students observe the water rise inside the jar when the candle flame goes out.

Explanation: The burning candle warmed up the air molecules causing the air to expand and some air to escape out the bottom of the jar. When the flame goes out, the air cools, condensing and creating an area of lower pressure inside the jar (a partial vacuum). The higher atmospheric pressure outside the jar pushes on the water surface forcing water molecules to move to the area of lower pressure inside the jar.

Guiding Questions

1. Describe how a vacuum works. How is this similar and different to how a suction sampler works?
   - ✓ **Possible answers:** Many vacuums operate by electric motor. When the motor is on it powers a fan with angled blades that forces air forward towards an exhaust port. When the air molecules move forward they create a higher density of molecules in front of the fan and a lower density behind the fan. This causes a decrease in pressure inside the machine, creating a partial vacuum. Air will move from the outside of the vacuum to the inside through an intake port. Air molecules will bring tiny pieces of dirt and debris with them cleaning the surface the vacuum is in contact with. Oceanographic samplers also run via electrical motor and have a pump which can be controlled from the ship to change the level of suction power needed to collect various organisms. Suction samplers are designed to be attached to underwater vehicles and work in an underwater environment. Both tools create a drop in pressure to collect materials.

2. What other kinds of samples can be obtained from a suction sampler?
   - ✓ **Possible answers:** Samplers can also be utilized to collect sediment and debris from the water column, and small pieces of rock or gravel.

3. Describe three types of information that can be learned by collecting biological, chemical or geological samples from the deep sea.
   - ✓ **Possible answers:** Biological: classifying new species based on genetic analysis; broadening phylogenetic tree, understanding adaptations based on environment, microscopic plankton analysis; Chemical: analysis of organism tissue samples to track pollutant or other chemical levels, DNA and protein analysis of various organisms, Geological: studying patterns in deposits to figure out how they formed; better understanding of tectonic processes such as faulting and landsliding; radiometric dating of geological samples.

Extensions & Adaptations

Introductory | Inform students that suction power for *Hercules*' sampler is controlled from the ship. If the scale of power is 1-10 where 10 is the highest power, have students predict which level should be used to collect the following samples:

- Small jellyfish (less than 5")
- Sea urchin
- Small squid (less than 10" length)

Ask students to choose the best tool for removing various objects from water: egg yolks, shredded paper, glitter, or pebbles. Tools can include empty water bottles, straws, and empty condiment dispensers.

Which tool worked best for each sample? Ask students to describe what factors engineers should consider when designing a device to collect various sized objects and organisms from the deep sea.

Define the following terms:

Students will be able to understand and use the following vocabulary:

Exhaust Port

- ✓ The opening which allows air to escape or leave from the inside of the vacuum. Helps to maintain lower air pressure inside the vacuum.

Fauna

- ✓ All the animals that live in a particular area.

High Pressure

- ✓ An area that has a greater number of molecules per unit space

Low Pressure

- ✓ An area that has a lower number of molecules per unit space

Partial Vacuum

- ✓ An enclosed space from which part of the air or another gas has been removed; creates an area of lower atmospheric pressure

Pressure

- ✓ The force per unit area.

Sample Jar

- ✓ The component of a suction sampler that is used for collecting and trapping specimens.

Subsample

- ✓ A sample taken from a larger sample. One oceanographic sample can yield many additional subsamples.

Extensions & Adaptations

Advanced | Students can research another pressure-based device and give a detailed written or verbal report on how the engineering of the machine allows it to function.

Students can interview a scientist or engineer who works with or designs oceanographic samplers or other instruments and share their conversation with the class.

Ask students to complete a gallery walk to observe other groups' designs and data. Students can discuss or write about modifications they would make to their current design based on their findings.

Interdisciplinary | Physiology: Students can research an organism's adaptation that relies on changeable pressure to function (e.g. human lungs or sea star tube feet). Present new findings to the class.

Additional Resources | http://oceanexplorer.noaa.gov/technology/tools/suction/s_d_sampler.html

Activity/Tasks

Students will:

- Read the introduction, answer the guiding questions and complete the vocabulary.
- Divide into small groups and establish group roles.
- Create a sampler design to complete challenges one and two.
- Collect data and complete analysis questions.

Educator: Lesson Procedure/Directions

✓ **LESSON SET-UP |** It is suggested that students work in small groups to complete this module. It may be helpful to introduce the concepts of molecular movement such as Brownian motion, diffusion, and pressure prior to the start of this lesson. Refer to "Set the Stage" for a demonstration idea.

☐ Helpful tips:

- ✓ Have a central supply depot set up for each group to select materials. It may be beneficial to establish group roles (such as materials manager, timekeeper, data logger to ensure efficiency in collaboration)
- ✓ Fill bin 1 and bin 2 halfway with water. Add different sized materials to each (e.g. 10 rubber bands in bin 1, 10 chopped pipe cleaners in bin 2). Groups should have the same number and type of materials in corresponding bins so results can be compared throughout the class.
- ✓ Fill bin 3 halfway with water and sprinkle a small material into the water (e.g. pepper, glitter, sand or pencil shavings) Students will be asked to design a modification to their sampler to pick up this fine-grain material.
- ✓ Encourage a class discussion following the activity to compare sampling devices and efficiency of those devices. Students should be able to describe what parts of their designs worked well.
- ✓ View these examples of student-built samplers. [nautl.us/232ygKM]

Student Procedure

1. Determine work group arrangements and group roles (suggestions: team manager, materials manager, timekeeper, data logger).
2. Complete guiding questions and vocabulary terms using online and module resources.
3. Complete challenges one and two.
4. Complete the associated worksheets and analysis questions.

SUCK IT UP! | STUDENT

Learning Goals

- Design a tool that can utilize changes in pressure to collect various materials.
- Understand how changes in pressure can allow physical, biological and mechanical processes to occur.
- Learn about oceanographic tools, engineering and sampling techniques.
- Describe the importance of sampling in the deep sea.

THINK About It!

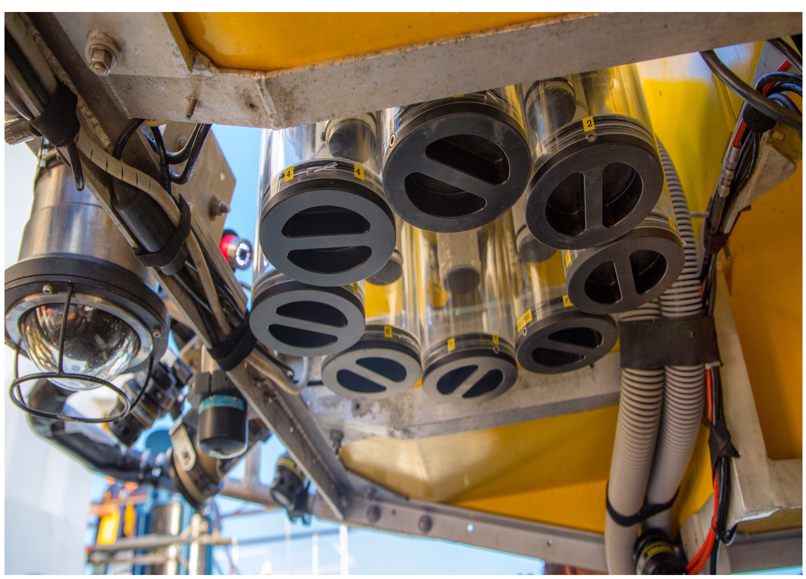
- *Can you think of another creature or tool that utilizes pressure changes to survive or operate? Describe below.*

Introduction | Imagine you are a scientist exploring the ocean's depths and you need to collect various organisms to investigate. How would you design a device capable of collecting biological fauna, sometimes very small creatures, from their watery habitat without damaging them? The *Nautilus* Corps of Exploration utilizes a tool called a suction sampler or slurp sampler to gather specimens. The suction sampler is attached to remotely operated vehicle (ROV) *Hercules* and controlled from the control van to collect organisms too delicate to grab with a manipulator claw like bacterial mats, fish, and crustaceans.

The sampler works on the same premise as a vacuum cleaner - a pump or fan creates low pressure inside a chamber; air and dirt move from high pressure to low pressure creating suction force pulling material into the vacuum cleaner. Learn more about vacuum basics [nautl.us/1V1veUm]. ROV pilots can change the power of the suction pump and rotate eight collection chambers to gather multiple unique samples. The suction pump speed changes the vacuum pressure within the system, drawing organisms into sample jars without damaging them.

Many organisms in the natural and physical world rely on changing pressure mechanisms to survive and function. Humans' muscular diaphragm, located between the thoracic and abdominal cavity, contracts every breath providing the necessary drop in pressure to inhale air. Fresh air moves from higher atmospheric pressure to the lower pressure within the lungs. Sea stars pump water around the hydrostatic skeleton to change internal pressure and push out their tube feet to maneuver through their environment.

In this module, you will learn how pressure changes affect the movement of molecules and will design, build, and test your own suction sampler device.



View from below of the ROV *Hercules*' suction sampler. Notice the eight rotating chambers which keep sample organisms apart from each other.

Watch the suction sampler in action! http://nautl.us/28N633a

Super Samples:

Check out some of the unique fauna collected by the slurp sampler during the 2015 Galápagos Expedition.

Deep Sea Arthropod

Deep Sea Urchin

Deep Sea Echinoderm

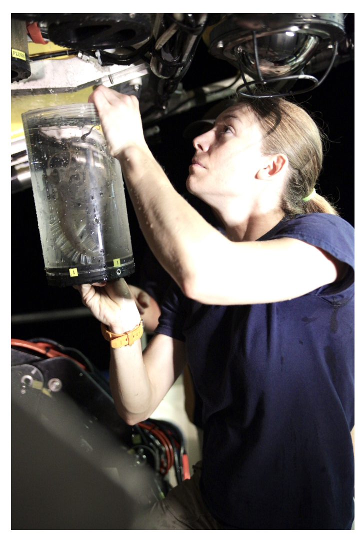
Guiding Questions |

1. Describe how a vacuum works. How is this similar and different to how a suction sampler works?

2. What other kinds of samples can be obtained from a suction sampler?

3. Describe three types of information that can be learned by collecting biological, chemical or geological samples from the deep sea.

Suction sampler canisters are removable to make it easy to bring organisms into the E/V *Nautilus* wet lab for analysis. At right, Nicole Raineault, Director of Science Operations for the Nautilus Exploration Program, removes a chamber and sample after a dive during the 2015 Galápagos Expedition.



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NAUTILUS NEWSFLASH

The Nautilus Exploration Program collected over 2,300 subsamples from 688 individual samples - a record number - during the 2015 field season. The newly designed suction sampler was a large part of this effort. Most small, mobile, fragile animals are nearly impossible to sample using a ROV manipulator arm. The new suction sampler system allows collection of up to eight separate samples in one dive. Applied use of different mesh sizes on the sample jar exhaust ports optimizes collection of different-sized organisms, from bacterial mats to fish.

After returning to deck, scientists and interns work diligently to separate each type of organism from sample jars and take subsamples of each for preservation. Different preservation techniques are used depending on the classic, genetic, or taxonomic analyses planned for each animal.

Vocabulary |

Exhaust Port:

Fauna:

High pressure:

Low pressure:

Partial vacuum:

Pressure:

Sample jar:

Subsample:

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VOICES IN STEM

Dr. Nicole Raineault
Director of Science Operations,
Ocean Exploration Trust

"Although I have always been interested in exploring the depth of the ocean, I never would have predicted I would wind up organizing and leading deep-sea oceanographic exploration cruises. Although the at-sea and technological aspects of my work provide constant challenges, the reward for going where no one else has been and using new tools to gather data is immense. Exploration is the essential first step in the scientific method before hypothesis-driven science can occur. The Nautilus team gathers the data to drive scientific research in previously unexplored regions. It is rewarding to learn how to utilize technology to efficiently and effectively gather information in the deep sea. I highly encourage young scientists to delve into the challenging unknown. Take advantage of opportunities to learn more independently or through volunteer, after school, and summer programs. The ocean abounds with discoveries!"

Materials |

Each group will need the following:

- 3 numbered bins filled halfway with water and assorted sized objects
- Empty container for holding "sampled"objects
- Various sizes of tubing
- Laboratory latex or non-latex gloves
- Mesh
- Rubber bands
- Duct tape
- Plastic cups/water bottles with one end removed or modified
- Straight or bendable straws

Procedure |

1. Examine the materials available to your group and come up with a design plan for your own suction sampler that is able to collect various sized objects in the bins of water.
2. Build your device. Test it to see if it works, then complete the two challenges below:
3. Challenge One: Time crunch challenge- use your device to collect all materials from bin one and transfer them to an empty container. Record the time it took your device to complete this trial. Return the samples to the bin. Now, considering your results, you can make one modification to your design to improve your sampling time. Repeat the sampling and record time for trial two. Note observations about how well your device functioned below the data table.
4. Repeat Challenge One sampling material from bin two, noting times and observations on Challenge One worksheet.
5. Challenge Two: Tiny creature challenge- Bin three holds tiny particle pieces that need to be collected. Make modifications to your suction sampler using the materials provided to create a tool ready to collect these tiny samples. When your design is ready, you will have two minutes to use the sampler to gather as much target material as possible. Sketch and label your design and record data and observations on Challenge Two worksheet.
6. Complete student analysis questions.

Challenge One Worksheet

Sketch or show pictures of your sampling tools below:

Bin 1 - Initial Design	Bin 2 - Initial Design
Bin 1 - Modified Design	Bin 2 - Modified Design

	Bin 1	Bin 2
Initial model’s time (min, sec)		
Modified model’s time (min, sec)		

Notes and observations:

Challenge Two Worksheet

Sketch your suction sampler design plan below. Label all components; note new modifications made for this challenge:

Describe the modification(s) you made to your original design to make it suited for this challenge	
Estimate the percentage of the tiny particles your sample collected in two minutes	________________ % material collected
Notes & Observations *What is working well?* *What are the weak elements of my design?* *This would work better if…*	

Analysis Questions |

1. Describe some similarities and differences between your suction sampler and the sampler used on ROV *Hercules*. Read this **sampler guide** [nautl.us/1M12edK] to get better acquainted with the engineering of the *Hercules* sampler system.

2. Using the vocabulary words defined in the introduction, describe the step-by-step process of how your suction sampler gathered material out of the water.

3. Based on what you learned as an engineer in this module, describe two challenges engineers must keep in mind while designing oceanographic samplers or instruments.

4. Summarize why the movement of molecules from high pressure to low pressure is important to biological, physical, and mechanical processes.

SUCK IT UP! | ASSESSMENT

STEM Project & Task Rubric

OBJECTIVE	**CRITERIA**			
	4 Exemplary	3 Commended	2 Emerging	1 Developing
Knowledge & Understanding |	Student consistently, correctly and thoroughly answers all questions. Uses an abundance of relevant vocabulary and is able to explain relationships within the content using examples. Can apply the content to other topics or real life.	Student is able to consistently answer most questions correctly. Uses an adequate amount of relevant vocabulary. Can explain relationships within the content and can apply content to other topics or real life.	Student is able to answer some questions correctly. Uses some relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.	Student is able to answer a few questions correctly. Inconsistently uses relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.
Content Organization, Methodology & Analysis |	Student effectively organizes complex ideas, concepts, and information to make important connections and distinctions. This may include detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student is able to organize ideas, concepts, and information to make connections and distinctions. This may include mostly detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student attempts to organize ideas, concepts and information to make some connections and distinctions. Student is able to provide basic procedures, data tables, graphs, diagrams and/or analyses.	Student has difficulty organizing ideas, concepts and information to make connections and distinctions. Student is unable to provide basic procedures, data tables, graphs, diagrams and/or analyses.
Self-Directed Learner |	Student is actively engaged in the learning process; consistently contributes to class discussions and asks clarifying questions. Seeks out and shares additional resources with the class or teacher. Advocates for his/her learning needs.	Student is engaged in the learning process. Often contributes to class discussions and asks clarifying questions. Advocates for his/her learning needs.	Student is inconsistently engaged in the learning process. Sometimes contributes to class discussions or asks clarifying questions. Inconsistently advocates for his/her learning needs.	Student is weakly engaged in the learning process. Rarely contributes to class discussions or asks clarifying questions. Rarely advocates for his/her learning needs.
Technological Tools |	Use of digital resources is always appropriate for the task. Willing to learn and use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is appropriate for the task. Willing to use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is sometimes appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is rarely appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.
Collaboration Skills |	Consistently works effectively and respectfully with a diverse group of learners. Actively checks with others for understanding and how he or she may be of help. Student listens when others speak and incorporates or builds off of the ideas of others.	Works effectively and respectfully with a diverse group of learners. Checks with others for understanding and how he or she may be of help. Student listens when others speak.	Sometimes works effectively and respectfully with a diverse group of learners. Sometimes checks with others for understanding and how he or she may be of help. Student listens when others speak.	Has difficulty working effectively and respectfully with a diverse group of learners. Rarely checks with others for understanding and how he or she may be of help. Student may talk over other students or does not listen when others speak.
Total Score: __________	**Comments:**			

HOW LARGE IS NAUTILUS NATION?

Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.

Name: **My Community (City, State):**

Email Address:

School's Name:

Instruction date: **Grade level instructed:**

Subject area:

My education space is a...

- ❏ Classroom
- ❏ After school program / Club meeting
- ❏ Fair / Festival / Event
- ❏ Museum / Science Center
- ❏ Other. Tell us more:

Who did you engage in your teaching?

Students

Community Members

Select all the OET materials you used in your instruction:

- ❏ STEM Learning Modules. Which ones? ____________________
- ❏ Digital Resource Library materials. Which ones? ____________________
- ❏ Nautilus Live website: photo albums ❏ highlight videos ❏ live stream
- ❏ Meet the Team STEM mentor profiles
- ❏ Facebook (NautilusLive) ❏ Twitter (@EVNautilus) ❏ Instagram (@nautiluslive)
- ❏ Other. Tell us more: ____________________

____

What made working with OET resources valuable to your instruction (select all that apply)?

- ❏ Hands-on activities ❏ STEM career connections
- ❏ Easy to use lessons ❏ Standards-based lessons
- ❏ Website resource access ❏ Real world application of curricula topics
- ❏ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❏ Another reason. Tell us more: ____________________

____

Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects.	❏ Yes	❏ No
OET provided me with helpful and relevant teaching resources.	❏ Yes	❏ No
Using OET resources increased my awareness of STEM careers.	❏ Yes	❏ No
If yes, how so? How can we improve?		

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

THANK YOU FOR ALL YOU DO!