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Nature's Cleanup Crew: How Marine Microbes Purify Our Oceans



BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

Project Number: KA220-BW-23-30-126516

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Introduction

This exercise introduces students to the hidden world of marine microorganisms, Earth's smallest yet most essential environmental engineers. Oceans contain vast communities of bacteria, algae, and other microbes that play a crucial role in maintaining the planet's balance by breaking down pollutants, recycling nutrients, and supporting marine ecosystems. These microscopic life forms act as nature's cleanup crew, transforming harmful substances such as oil, plastic residues, and organic waste into harmless or even beneficial compounds.

Using Augmented Reality (AR), students will dive beneath the ocean's surface to explore the microbial ecosystems that purify the ocean. They will observe how different types of microbes function within the marine environment, visualize how these organisms interact with pollutants, and discover the biochemical processes behind biodegradation and bioremediation.

This interactive learning experience connects biology, environmental science, and chemistry within a STEAM framework, helping students understand how natural processes can inspire technological solutions for sustainable environmental management. By the end of the exercise, students will recognize the importance of microbial life in ocean health and reflect on how humans can learn from these biological systems to design eco-friendly cleanup technologies and biomimetic approaches for pollution control.

This document consists of the following points:

- Information about AR technology
- How to define AR exercise thanks to the template:
 - General information
 - Pedagogical specifications
 - Technical specifications



General information

<p>Name of the exercise:</p>	<p>Nature's Cleanup Crew: How Marine Microbes Purify Our Oceans</p>
<p>Description of the exercises:</p>	<p><i>This exercise immerses students in the unseen yet powerful world of marine microorganisms that act as nature's cleanup crew. Through Augmented Reality (AR), students explore how bacteria, algae, and other microscopic organisms help maintain ocean health by degrading pollutants, recycling organic matter, and supporting aquatic ecosystems.</i></p> <p>By interacting with 3D AR models, students can visualize how microbes attach to pollutants, secrete enzymes, and break down toxic substances like oil, plastic residues, and organic waste. They will also explore the biochemical processes of bioremediation, understand the food web connections involving microorganisms, and observe how environmental factors (temperature, oxygen, light) influence microbial activity.</p> <p>The exercise combines exploration, analysis, and reflection to promote a systems-level understanding of marine ecosystems and their resilience. Students will also discuss how insights from microbial processes can inspire bio-inspired technologies for cleaning up water bodies and mitigating pollution.</p>
<p>Participants:</p>	<p>This exercise can be completed by individual students or small collaborative groups (3–5 students). Group work is encouraged to stimulate discussion about ecological systems, sustainability, and bio-inspired design solutions.</p>



Participants' age
range:

Minimum 14 years old

Students should have a basic understanding of microorganisms, ecosystems, and pollution from general science or biology classes.

STEM subject and
specific topic:

STEM Subject: Biology, Environmental Science, Chemistry

Specific Topic: The role of marine microbes in cleaning and maintaining ocean ecosystems (bioremediation, biodegradation, nutrient cycling).

Main challenge (stressful aspect) of the topic:

The most challenging aspect of this topic is that microbes are invisible to the naked eye and their biochemical processes are difficult to visualize. Students often struggle to imagine how microscopic organisms can have large-scale impacts on ocean health and pollution reduction. Additionally, understanding the complex interactions between microbial species, pollutants, and environmental factors requires abstract reasoning about molecular-level processes.

How AR helps simplify the concept:

- **3D AR visualization** makes invisible microorganisms visible, helping students observe microbial forms, habitats, and interactions with pollutants.
- **AR animations** show how microbes attach to oil particles, secrete enzymes, and decompose pollutants step by step.
- **Layered AR scenes** illustrate the relationship between microbial activity, ocean layers, and ecosystem health.
- **Interactive overlays** explain key biochemical processes (e.g., oxidation, enzymatic degradation) in a simplified and engaging way.
- **Gamified exploration** encourages students to clean a virtual ocean by selecting microbes suited for different pollutants, reinforcing applied learning.

Pedagogical Aim (Learning Outcomes):

By the end of this exercise, students should be able to:

1. Explain the role of marine microorganisms in ocean ecosystems and pollution cleanup.
2. Describe bioremediation and how microbes transform harmful substances into harmless ones.



Gamification
process:

3. Identify factors affecting microbial efficiency, such as temperature, salinity, and oxygen levels.
4. Understand the connection between microbial processes and global environmental health.
5. Reflect on how nature-inspired microbial strategies can be applied to human-designed cleanup technologies.

- **Challenge-based learning:** Students complete tasks to identify the right microbes for different types of pollutants in AR simulations.
- **Points and badges:** Awarded for successfully “cleaning” virtual ocean areas or identifying microbial processes.
- **Scenario progression:** Students advance through stages representing different marine environments (e.g., coastal, deep sea, polluted zone).
- **Final Reflection:** Students summarize how microbial activity contributes to ecosystem balance and propose one bio-inspired cleanup idea.

Written or graphic
description of
Augmented info:

The AR experience includes:

- **Interactive 3D models** of marine microbes (bacteria, algae, protozoa) shown in different scales and habitats.
- **AR animations** visualizing how microbes break down pollutants (e.g., oil droplets, plastic microfibers).
- **Pop-up text** describing microbial functions, biochemical reactions, and ecological importance.
- **Dynamic ocean environment scenes** that change based on pollution levels and microbial activity.
- **Simulation controls** that allow students to adjust conditions such as temperature or oxygen and see how microbial efficiency changes.

External (or extra)
tools required

- **AR-compatible devices** (smartphones, tablets).
- **Delightex platform** for hosting and viewing AR content.
- **Internet access** for loading interactive materials and environmental animations.
- Optional:
- **Worksheets for note-taking and reflection.**



External video resources, such as “The Hidden Cleaners of the Ocean Microbe Arm”

Links (video,
images, text online
and so on).

Video: The Hidden Cleaners of the Ocean Microbe Arm

Link: https://youtube.com/shorts/AyNvAIE_EU?si=IkaU9hivH0onAx11



Pedagogical specifications

Here we will collect information on how to use the exercise in the learning session and the results and benefits of using it, from a pedagogical perspective.

[How can this augmented information be used to address a STEAM topic in a more interesting way for students?](#)

Interactive 3D Models

Goal:

Help students visualize and interact with detailed 3D models of **marine microbes** and their interaction with pollutants to understand how these microscopic organisms purify the ocean and sustain marine ecosystems.

Use:

Students can zoom in, rotate, and explore **3D AR models** of various marine microorganisms, including bacteria, algae, and protozoa, to view their shapes, habitats, and functions. By tapping on specific microbes (e.g., *oil-degrading bacteria* or *algae involved in oxygen production*), students trigger **animations** that show how microbes attach to pollutants, secrete enzymes, and break down contaminants like oil droplets or microplastics.

Interactive overlays provide simplified explanations of **biochemical processes** (oxidation, decomposition, and nutrient cycling) and highlight how microbial cooperation supports **environmental balance**. This hands-on visualization makes invisible biological phenomena tangible and engaging.

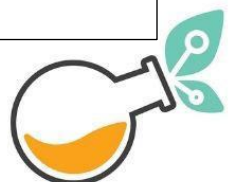
Interactive Buttons

Goal:

Enable students to actively engage with AR models to better understand the **ecological and chemical mechanisms** of bioremediation in marine environments.

Use:

Students can tap on interactive buttons within the AR scene to trigger pop-up explanations or switch between different marine settings, such as a clean ocean, a polluted zone, and a restored habitat. Each button may represent a condition (e.g., temperature rise, oil spill, oxygen depletion), allowing students to observe how microbial efficiency changes under environmental stress. Additional buttons let students select specific microbial types or visualize the **before-and-after** effect of microbial cleanup. Progress tracking ensures students move through the learning stages systematically, from exploring microbial forms to understanding their biochemical functions and finally to applying these insights to STEAM-based environmental problem-solving.



Possible Classroom Session Plan

Introduction (5–7 mins)

Goal: Introduce students to the concept of marine microbes as “nature’s cleanup crew.”

- Begin with a real-world question: *“If an oil spill happens in the ocean, what happens to the oil over time?”*
- Show a short video (e.g., “The Hidden Cleaners of the Ocean Microbe Arm”).
- Discuss everyday examples of pollution and ask students how they think the ocean recovers naturally.

Main Activity – AR Exercise (30-35 mins)

Exploring Marine Microbes and Bioremediation with AR

1. AR Model Interaction (10–15 mins):

- Students scan a QR code or open the Delightex AR app to access interactive 3D models of marine microbes.
- **Hands-on Exploration:**
- Rotate and zoom in on different microbes (bacteria, algae, protozoa).
- Tap on microbes to reveal pop-up explanations (e.g., “How bacteria degrade oil,” “How algae recycle oxygen”).
- Observe how microbial communities interact with pollutants and adapt to changing environments.

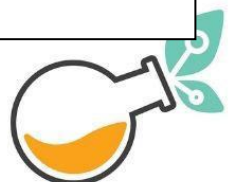
2. Guided Learning Tasks (10–15 mins):

- Watch an AR animation showing microbes decomposing pollutants in different ocean zones.
- Conduct a virtual experiment: adjust environmental variables (temperature, oxygen, pollution type) and observe the effect on microbial efficiency.
- Gamified Challenge: “Clean the Virtual Ocean” — students select the right microbes to restore ocean health.
- Encourage teams to discuss how these natural processes could inspire bio-based water treatment or pollution control technologies.

Conclusion & Recap (10-15 mins)

Goal: Reinforce learning through discussion and reflection.

- Project the AR environment on a shared screen and discuss outcomes.
- Ask students:
 - *Which microbe was the most effective in cleaning pollutants?*
 - *How do environmental conditions affect microbial activity?*
 - *What can humans learn from nature’s cleanup systems?*
- Reflection Task: Write a short paragraph answering:
“How can the role of marine microbes inspire the design of sustainable water-cleaning technologies?”
- End with a discussion on how STEAM learning connects biology, chemistry, and technology in addressing environmental challenges.
- End with a discussion about bio-inspired design and how studying natural systems can lead to sustainable technological innovations.



Which pedagogical objectives are addressed through this scenario?

Active Engagement

Students actively engage with 3D AR models of marine microbes and ocean environments, allowing them to zoom in, rotate, and explore how microscopic organisms interact with pollutants. This hands-on experience fosters curiosity and exploration, helping students visualize how microbes attach to oil particles, secrete enzymes, and break down contaminants.

By interacting with animations and pop-up explanations, students directly connect theoretical knowledge of biology and chemistry with real-time visual simulations of how microbial life supports ocean health. This direct engagement makes abstract microbiological and environmental processes tangible and exciting, encouraging students to take an active role in understanding the natural mechanisms behind bioremediation.

Critical Thinking

The exercise promotes critical thinking by encouraging students to analyze how different environmental factors (temperature, salinity, oxygen level, or pollution type) affect microbial performance. Through the AR experience, students can experiment virtually with variable conditions and compare microbial efficiency across scenarios. This encourages reasoning about cause and effect, ecological balance, and the interconnectedness of biological and chemical processes. Students must think critically about why some microbes thrive in polluted environments while others die, and how such natural systems can inspire human-designed environmental technologies for cleaning up pollution sustainably.

Application of Knowledge

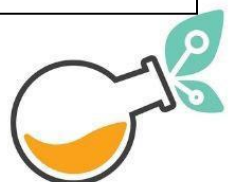
By interacting with AR simulations, students apply their understanding of biological degradation, chemical reactions, and ecosystem dynamics in a practical, visual context.

The activity challenges them to integrate STEM and environmental knowledge, linking molecular-level microbial processes with macro-level ecosystem outcomes (such as cleaner oceans and healthier marine life). Students also connect natural principles to technological innovation, brainstorming how biomimicry, learning from microbial systems, can lead to eco-friendly water purification and waste management solutions. This applied learning reinforces comprehension and deepens their appreciation of real-world sustainability challenges.

Multimodal Learning (Visual, Hands-On, Inquiry-Based Learning)

The scenario integrates visual animations, hands-on AR exploration, and inquiry-based learning to appeal to multiple learning styles. Students engage through observation, experimentation, and reflection, transforming abstract microbial and chemical concepts into concrete, observable experiences. The combination of visual storytelling (through animations) and interactive decision-making (through AR tasks) ensures that learners grasp complex STEAM topics, such as bioremediation, microbial ecology, and pollution management, in a meaningful and memorable way.

This multimodal approach empowers students to understand not only how marine microbes function but also why their role is vital to sustaining life on Earth.



Which results are expected to be reached with its use?

Enhanced Understanding of Marine Microbial Processes and Ocean Health

Students will develop a deeper understanding of how marine microorganisms contribute to environmental balance and the purification of polluted waters. Through interactive 3D AR visualizations, they will observe in detail how bacteria and algae degrade pollutants, recycle nutrients, and support marine ecosystems. This immersive, visual experience helps students connect microscopic biological processes (such as enzymatic degradation and oxidation) with macroscopic environmental outcomes, reinforcing theoretical knowledge through observation and active participation. By the end of the activity, students will understand how invisible microbial activity sustains visible ecological stability and why protecting these microorganisms is critical for global ocean health.

Increased Engagement and Interest in Environmental Science and STEAM Fields

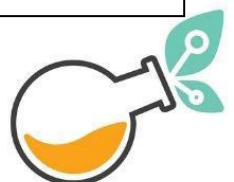
The interactive and exploratory nature of the AR experience is designed to spark student curiosity and motivation in biology, chemistry, and environmental technology. By transforming an abstract concept, microbial bioremediation, into a visually engaging and participatory learning experience, students are more likely to develop a positive attitude toward scientific inquiry and sustainability research. They will also gain awareness of how interdisciplinary STEAM learning (combining science, technology, engineering, and art) can inspire innovative approaches to climate resilience and pollution management. This heightened engagement encourages long-term interest in marine biology, biotechnology, and ecological design.

Improved Retention and Recall of Key Concepts

The combination of animated simulations, interactive exploration, and gamified challenges helps enhance students' retention and recall of essential concepts, such as biodegradation, nutrient cycling, and microbial ecosystems. The multisensory learning approach, integrating visual, tactile, and cognitive engagement, supports long-term comprehension by linking theory with observation and practice. As students visualize how different microbes respond to environmental stress or pollutants, they gain a clearer mental model of complex biochemical interactions. This hands-on exploration ensures that scientific principles are not only memorized but understood through experience.

Increased Confidence in Explaining Bio-Inspired and Environmental Applications

The combination of animated simulations, interactive exploration, and gamified challenges helps enhance students' retention and recall of essential concepts, such as biodegradation, nutrient cycling, and microbial ecosystems. The multisensory learning approach, integrating visual, tactile, and cognitive engagement, supports long-term comprehension by linking theory with observation and practice. As students visualize how different microbes respond to environmental stress or pollutants, they gain a clearer mental model of complex biochemical interactions. This hands-on exploration ensures that scientific principles are not only memorized but understood through experience.



Technical specifications

AR INFORMATION

Technology

Markerless AR (no need for a printed marker).

If it's needed a
marker, description
of the marker



Hardware and
software needed:

Hardware: PC, smartphone, tablet (for accessing AR content), Camera (for AR functionality), Gyroscope (for AR tracking on mobile devices).

Software: The **Delightex** AR web-based viewer or mobile app, compatible with both **iOS** and **Android**.

Type of Augmented
data

- **3D models** of marine microbes (e.g., bacteria, cyanobacteria, algae) and pollutants (oil droplets, microplastics).
- **Animated visualizations** showing microbial biodegradation processes (enzyme release, breakdown of hydrocarbons, nutrient recycling).
- **Pop-up text overlays** explaining microbial species, chemical reactions, and ecological roles.



Written description
of the AR data

- **Dynamic background scenes** representing different marine environments (open ocean, coastal zone, polluted area).
- **Interactive sliders** for changing environmental conditions (temperature, oxygen, salinity, pollutant type).
- After launching the AR experience, students see a **3D underwater environment** populated by animated **microbes and pollutants**. The main title “*Nature’s Cleanup Crew: How Marine Microbes Purify Our Oceans*” appears, inviting students to begin the simulation.
- Students interact with the content by:
 - **Zooming in and rotating** to explore microbe morphology and habitat.
 - **Tapping** on pollutants (e.g., oil droplets or plastic particles) to watch microbes attach and begin degradation.
 - **Triggering pop-up explanations** describing what happens at each stage of the cleanup process, e.g.:
 - “Bacteria release enzymes that break down hydrocarbons.”
 - “Algae convert waste into oxygen and nutrients.”
- **Adjusting conditions** (temperature, oxygen levels) to observe microbial response.
- **Comparing before-and-after ocean visuals** to assess bioremediation success.
- As the simulation progresses, students watch AR animations showing decreasing pollution levels and increasing water clarity, symbolizing the ocean’s recovery. A reflection panel appears at the end to prompt students to describe how microbial systems inspire biomimetic solutions for pollution management.
- **Additional features:**
 - **An animated sequence** showing the step-by-step process of how marine microbes detect, attach to, and break down pollutants such as oil or plastic particles, visualizing the gradual purification of ocean water.
 - **A bio-inspired technology section**, where students can explore how microbial processes inspire human innovations in sustainable wastewater treatment, oil spill cleanup, and environmental engineering.
 - **A “Return to Start” button** allowing users to reset the simulation and revisit earlier stages of the exercise, enabling repeated exploration of microbial interactions under different environmental conditions.



Scene

Four scenes:

Scene 1: The Hidden World of Microbes

Students explore a 3D ocean scene showing various microbial types floating among organic particles. Pop-ups introduce bacteria, algae, and protozoa, explaining their ecological roles. Navigation arrow → Scene 2.

Scene 2: Pollution in the Ocean

Students encounter visualized pollutants (oil droplets, microplastics). Interactive hotspots allow tapping to trigger animations showing how pollutants affect water quality and marine life. Navigation arrow → Scene 3.

Scene 3: Microbial Bioremediation in Action

Students activate AR animations showing microbes attaching to and breaking down pollutants. Pop-up explanations describe enzymatic degradation and chemical transformation processes. Navigation arrow → Scene 4.

Scene 4: Ocean Recovery and Reflection

Students view a “cleaned” ocean scene. Animated microbes cycle nutrients while fish and coral return. A reflection question appears: *“How do microbes maintain ocean balance, and what can we learn from them?”*
A “Return to Start” button resets the AR sequence.

If Image

-

If Text

What Are Marine Microbes?

Marine microbes are microscopic organisms that live in oceans and play essential roles in nutrient cycling and pollution cleanup.

How Do They Clean the Ocean?

Certain bacteria and algae can break down pollutants like oil and plastics through biochemical reactions, converting toxic compounds into harmless materials.

Why Are They Important?

Without these microbial processes, pollutants would accumulate, disrupting marine life and oxygen production. Microbes act



as natural recyclers, maintaining ecological balance and supporting biodiversity.

What Can Humans Learn from Them?

Understanding microbial processes inspires bio-inspired technologies for sustainable waste treatment and water purification, leading to cleaner environments.

If video

-

If audio

-

If 3D model



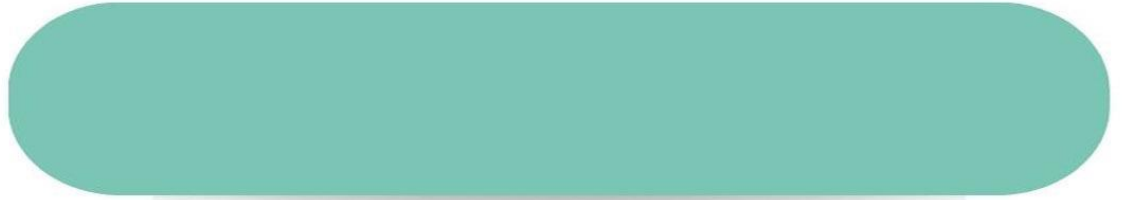
Delightex

<https://edu.delightex.com/MMY-TDR>



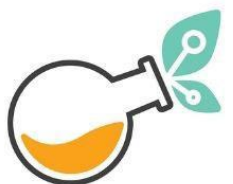


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