Lesson 1 of 5 : Mission Background

Duration: 45 minutes

Digital Science Journal:

Tutorial (Page 1)

Mission Background (Page 2)

More About Snails (Page 3)

Virtual Reality:

View Hunt

NGSS PerformanceExpectations:

Contributes to MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Students who demonstrate understanding can:

- Summarize how venomous marine snails hunt prey
- Recall that marine snail venom is being studied with applications for medicinal uses in humans
- Generate questions based on observations of venomous marine snails' habitat, food sources, and hunting techniques
- Identify three types of venomous marine snails prey
- Predict two types of venomous marine snails predators
- Select water turbidity levels in venomous marine snails habitats

Context for Lesson:

In Lesson 1, students are introduced to the Digital Science Journal (DSJ) and Virtual Reality (VR) components of BioDive.

They will have several opportunities to view the anchoring phenomena of venomous marine snails stunning and eating prey, as videos and in virtual reality. News articles will provide more context about where the marine snails live, and why researching them is important to human beings.

By documenting and making observations, students also learn how to identify different aspects of marine ecosystems and practice asking questions to guide further inquiry.

This lesson extends student knowledge around predator prey relationships and provides concrete representations and manipulatives of food chains in a single ecosystem. This will prepare students to understand and describe the impact of abiotic and biotic variables on ecosystems.

Student Prior Knowledge:

Before beginning this lesson students should know:

- What devices they will be using throughout this experience
- The locations of their laptops/iPads and VR headsets
- The routine for distributing and collecting devices.

Potential misconceptions:
The specific content about venomous marine snails will probably be unfamiliar to most students, and misconceptions may come from prior knowledge about garden snails or other marine creatures.

The venomous marine snails' habitat (tropical waters), size (3-4 inches in length), and levels of aggression (not aggressive toward humans) may all motivate students' initial questions, and will be addressed through the material or in discussions.

SEP:

Asking Questions and Defining Problems

Developing and Using Models

DCI:

LS2.A: Interdependent Relationships in Ecosystems

CCC:

Patterns

Cause and Effect

Activity	Learning Experience	Duration
Direct Instruction	Students are introduced to BioDive and how to use the DSJ and VR, collect their devices, and log in.	10 Minutes
DSJ Tutorial, Mission Background	Students complete the tutorial, observe the anchoring phenomenon, and develop questions about venomous marine snails.	15 Minutes
VR View Hunt	Students observe venomous marine snails hunting three kinds of prey in an immersive VR experience.	5 Minutes (per student)
DSJ Dive Deeper	Students may want more time to explore, especially if this is their first experience using VR, so this section may be extended. Dive Deeper: Snail Attack 1 [video], Tourist Attacked [article], The Killer Snail Chemist [article], Breakthrough 1 [video], Snails Treat Cancer [article], Weaponizing Insulin [article]	15 Minutes
More About Snails	Students recall the venomous marine snails' prey and predict their predators to prime them for trophic level work later in the experience, and are introduced to the concept of turbidity in the snails' habitat. The Deeper Dive provides real-world context for biomedical research about venomous marine snails.	
Discussion	Class ends with a discussion about **observations**, questions, and defining problems. Science starts with making observations about our surroundings. Scientists then **ask questions** about observations. These questions help **define problems** that scientists are trying to solve. During this time, the teacher should also ask for students to share some of their questions that they developed. End with a recap of the experience, what worked/didn't in regards to: accessing devices, using devices, feeling prepared to learn with these tools tomorrow.	10 Minutes

Potential Discussion Questions:

1. **What are observations and why do you think they are important in science?** *A. Observations are things that you noticed within an environment. They are important because they are the first step in developing questions about how systems work.*
2. **What types of observations were we able to make with the venomous marine snails from the field (ocean) that we wouldn't have been able to do in a laboratory setting?** *Answers will vary, see the venomous marine snails interact in their natural environment*
3. **How can these observations help us protect the venomous marine snails and help scientists study them to create medicines?** *Answers will vary- see what venomous marine snails need to eat to survive, what kind of environment that is best for them to thrive, etc.*
4. **Why is it important for scientists to develop questions from observations and define specific problems they want to research?** *A. Defining specific problems allows scientists to have a clear path to design a controlled experiment to test the specific problem based on their observations.*
5. **Based on what you have observed so far, what are some of the abiotic (non-living) factors that are needed for a healthy reef?** *A. Low Turbidity, with coastal waters and lots of sunlight.*
6. **What are a few questions you have after watching the venomous marine snails hunt their prey?** *A. Answers may vary, see if students can determine why scientists may have been interested in studying these snails to check for understanding and prime for question 2.*
7. **Why are scientists studying venomous marine snails?** *A. Their deadly toxins can be turned into palliative (pain reducing) treatments for humans.*
8. **What are the three different types of prey these venomous marine snails hunt with their deadly toxins?** *A. Mollusks, fish, worms*
9. **What are some predators of venomous marine snails?** *A. Turtles and lobsters*

Duration: 45 minutes

Digital Science Journal:

Ocean Zones (page 4)

Ecosystem (page 5)

Seas Under Siege (page 6)

Trophic Levels (page 7)

Virtual Reality:

Start Dive

NGSS PerformanceExpectations:

Contributes to MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Contributes to MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Students who demonstrate understanding can:

- Classify and compare oceanic zones (Ocean Zones, pg 4)
- Identify organisms in their marine habitat (Ecosystem, pg 5)
- Predict essential features of a healthy marine ecosystem (Ecosystem, pg 5)
- Recognize organisms in a coral reef (Start Dive, VR)
- Compare organisms based on trophic levels (Start Dive, VR)
- Compare changes to biodiversity in the same ecosystem at two points in time (Seas Under Siege, pg 6)
- Categorize marine organisms by trophic level to distinguish between consumers and producers, autotrophs and heterotrophs (Trophic Levels, pg 7)

Context for Lesson:

Students are introduced to different ocean zones and observe how differences in abiotic factors influence the organisms that live in a habitat. Lesson 2 introduces the idea that industrial sites could threaten the venomous marine snails' habitat. This lesson increases student knowledge around oceanic zones, predator prey relationships, and provides concrete representations and manipulatives of food chains in a single ecosystem to prepare students to understand and describe the impact of abiotic and biotic variables on ecosystems.

Student Prior Knowledge:

Before beginning this lesson, students should know:

- The content from pages 1-3, especially the anchoring phenomenon of venomous marine snails hunting prey
- How observations help scientists define problems
- Ecosystems include both biotic and abiotic factors

Potential misconceptions:

This lesson introduces the narrative element of industrial activity affecting the marine ecosystem, and students may have misconceptions about the causal mechanisms behind changes in the ecosystem. Student may think abiotic factors have no effect on an ecosystem.

Students may believe coral is a producer, because it does not move and looks like a plant. However, coral is a primary consumer, and eats organisms like zooplankton to get their energy.

Students may get confused about which way the energy flows. Explain that energy flows start with the producer and flows to the primary, secondary, and tertiary consumers, then decomposers.

SEP:	DCI:	CCC:
Asking Questions and Defining Problems Developing and Using Models	LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycle of Matter and Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience	Cause and Effect Systems and System Models

Activity	Learning Experience	Duration
Direct Instruction	Review the anchoring phenomenon, how marine snail venom is used to create medicine for humans and students, and then guide students to log in to page 4 of their DSJ to continue their adventure.	5 Minutes
DSJ Ocean Zones	Students classify oceanic zones and predict what organisms might live there.	2 Minutes
DSJ Ecosystem	Students predict essential features of a healthy marine ecosystem.	2 Minutes
VR Start Dive	Students embark on a dive to a healthy marine ecosystem where they'll observe diverse organisms across a variety of trophic levels.	5 Minutes (per student)
DSJ Dive Deeper	Dive Deeper: C. muricata approaching [video], Hagfish slime expands [article], Dead Zones in the Ocean [article], C. muricata attacking [video], Creatures of the Deep [article], Ban Killing Sharks [article]	15 Minutes
DSJ Seas Under Siege	Students return to the DSJ to distinguish changes to biodiversity at two points in time.	2 Minutes
DSJ Trophic Levels	Students use their understanding to categorize organisms by trophic level.	4 Minutes
Discussion	Class ends with a discussion about observations students made at the healthy dive site with diverse organisms and the changes they observed in the same ecosystem when returning from their dive. Teachers can reinforce key concepts including trophic levels, turbidity, and ecosystems within oceanic zones while asking students to predict how variations in these factors might impact organisms in each ecosystem.	10 Minutes

Potential Discussion Questions:

1. **Which zone do you think the venomous marine snails live in, and why?** *A. Intertidal or pelagic because they receive sunlight to create food for the snails' prey.*
2. **How is a food chain different than a food web?** *A. Food webs contain many food chains. They both show how energy is passed through an ecosystem, but a food chain only shows one way energy flows in an ecosystem.*
3. **What do we call the organisms at the bottom of the food web? Where do they get their energy from?** *A. Primary producers. They are plants and algae and get their energy from the sun through the process of photosynthesis.*
4. **What is the name of the group of organisms that eat those producers?** *A. Primary consumers, which are also called herbivores.*
5. **What is the name of the group of organisms that eat primary consumers?** *A. Secondary consumers. They might be carnivores or omnivores.*
6. **What is the name of the group of organisms that eat secondary consumers?** *A. Tertiary consumers, they are usually carnivores.*
7. **Who are our top predators?** *A. Apex predators.*
8. **After looking at the two images, how would you define biodiversity?** *A. An ecosystem having a variety of different kinds of organisms.*

Duration: 45 minutes

Digital Science Journal:

DSJ: Energy Pyramid (8)

Biodiversity (9)

Build a Model (10)

Abiotic & Biotic (11)

Virtual Reality:

(none; students may catch up if they have missed classes)

NGSS PerformanceExpectations:

Contributes to MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Contributes to MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Students who demonstrate understanding can:

- Apply the 10% rule to the transfer of energy in an energy pyramid
- Recall how energy is lost at each stage of the energy pyramid
- Design an oceanic food web
- Match biotic and abiotic variables
- Compare changes in environment to impact on biodiversity of organisms
- Predict changes in the food web when it has been disrupted

Context for Lesson:

This lesson begins by introducing and providing the opportunity to apply the 10% rule of energy transfer. Students deepen their understanding of venomous marine snails' ecosystem, and synthesize the roles of organisms across trophic levels as they create their own model of a marine food web. The lesson culminates with students classifying biotic and abiotic variables to prepare for data collection during lesson 4.

Student Prior Knowledge:

Before beginning this lesson students should know:

- Predator-prey relationships
- How to interpret food webs and food chains

Potential misconceptions:
When learning about food webs, students may confuse energy transfer between trophic levels with matter transfer. Explaining the law of conservation of energy, and sharing that energy is lost between levels as heat may help clarify this concept. Students can also be confused between the direction that energy flows (the direction of the arrow).

Biotic factors are not just the specific organisms seen here, but all living components of an ecosystem. The role of an organism (producers, consumers, decomposers) is important to understanding the ecosystem.

SEP:

Developing and using models

Constructing explanations and designing solutions

Engaging in argument from evidence

DCI:

Interdependent relationships in ecosystems

Cycle of matter and energy transfer in ecosystems

Ecosystem dynamics, functioning, and resilience

CCC:

Cause and effect

Energy and matter

Stability and change

Activity	Learning Experience	Duration
Direct Instruction	Review the features of an ecosystem and the changes to biodiversity students observed at their dive locations. Then, students can better predict the impact of changes to specific trophic levels of an ecosystem. Students are invited to log in to their journals and continue their journey on page 8.	10 Minutes
DSJ Energy Pyramid	Students learn and apply the 10 percentages rule of energy transfer.	5 Minutes
DSJ Biodiversity	Students observe how changes in the number of organisms in each trophic level can affect the biodiversity of a marine environment.	5 Minutes
DSJ Build a Model	Students create a model of a food web, emphasizing the interconnected nature of predator-prey relationships. Through a series of prompts, students elaborate how changes to any role in the food web affects the entire food web.	7 Minutes
DSJ Abiotic & Biotic	Students differentiate between abiotic & biotic factors in preparation for the following day's VR experience collecting abiotic data.	5 Minutes
Discussion	Teacher facilitates a summative discussion around: Food webs, energy transfer, and the predicted impacts of biotic and abiotic variables on ecosystems.	10 Minutes

Potential Discussion Questions:

1. **What % of the energy from organisms is passed to their consumers?** *A. 10% of the energy gets passed on from trophic level to trophic level.*
2. **Where does the other 90% of the energy go?** *A. Some is stored within the tissue of the organisms. Some energy is used by the organisms themselves to grow, reproduce, move, etc. Some energy is also lost as heat energy during chemical reactions.*
3. **What group of organisms not pictured in this food web are responsible for recycling the materials back to the producers?** *A. Bacteria and fungi, our decomposers.*
4. **Can you think of an example of an ecosystem where we are removing the producers? Why are they being removed and what impact is that having on the stability of the ecosystem?** *A. Answers may vary depending on student background knowledge. Deforestation may be a common example that removes trees to build towns or farms. This decreases the amount of organisms (biodiversity) that can live in that area.*
5. **How are abiotic factors different from biotic factors?** *A. Abiotic factors are the nonliving chemical and physical factors that impact ecosystems. Biotic factors are the living components of ecosystems like animals and plants but also fungi and bacteria.*
6. **What is homeostasis?** *A. Homeostasis is the state of equilibrium when all components in an ecosystem are in balance and functional at their optimal levels.*
7. **How might temperature impact the marine ecosystem?** *A. Temperature changes greatly impact the distribution of marine life. When the temperature is too warm marine organisms are unable to survive.*
8. **How might changes in any of the abiotic factors impact the marine ecosystem?** *A. While many organisms can tolerate variations in variables like acidity, temperature, salinity, water clarity, or dissolved oxygen, significant changes can be detrimental to ocean life.*

Duration: 45 minutes

Digital Science Journal:

Dive Equipment (12)

Dive Locations (13)

Abiotic Data (14)

Modeling Predictions (15)

Virtual Reality:

Boat Scenes

NGSS PerformanceExpectations:

Contributes to MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Contributes to MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Contributes to MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Students who demonstrate understanding can:

- Apply knowledge of scientific tools to collect abiotic data at a dive site
- Judge the impact of varying abiotic variables of temperature, pH, salinity, water clarity, and dissolved oxygen on biodiversity in a coral reef habitat
- Construct a model of two coral reefs using abiotic data
- Using qualitative and quantitative data, infer how abiotic variables affected
- organisms at two different dive sites
- Justify predictions of dive sites using scientific terminology and reasoning

Context for Lesson:

Students apply their knowledge of scientific tools to collect and measure abiotic data and are asked to make inferences using their data to create a model predicting the impact of abiotic factors on the living organisms (biotic factors) at two different dive sites.

Student Prior Knowledge:

Prior to this lesson students should understand the interconnected relationship of organisms across trophic levels and be able to distinguish between biotic and abiotic variables.

Potential misconceptions:
Students may become confused over units (° C, ppt and mg/L). The target of the table is the comparison between dive sites, so students shouldn't focus too much on the units; they can still make comparisons without fully comprehending the units used.

Student may have trouble appreciating that more than one abiotic factor can be changed or affect the dive site at once, as they are only allowed to change one factor at a time (Abiotic Data, pg 14).

SEP:

Analyzing and interpreting data

Constructing explanations and designing solutions

Engaging in argument from evidence

DCI:

LS2.A: Interdependent Relationships in Ecosystems

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

CCC:

Systems and system models

Stability and change

Influence of engineering, technology, and science on society and the natural world

Activity	Learning Experience	Duration
Direct Instruction	Teacher primes students for the day by helping them recall the distinction between abiotic and biotic data and invites learners to sign in to page 12 and continue their mission culminating in data collection at two dive sites.	5 Minutes
DSJ Dive Equipment	Students learn about the tools they'll use to collect abiotic data at two dive sites.	5 Minutes
DSJ Dive Locations	Each student selects a dive region (e.g., Eastern Atlantic, Eastern Pacific, Indo-Pacific).	2 Minutes
VR Boat Scenes	Students collect abiotic data from a boat at their chosen dive site.	5 Minutes (per student)
DSJ Dive Deeper	The Great Pacific Garbage Patch [article], Strange-Looking Fish Washed up [article], Plastic Planet [article], Floating Garbage Collector [article], Aquatic Food Webs [article], Depths of the Ocean [video]	15 Minutes
DSJ Abiotic Data	Students compare data from abiotic factors at two dive sites, and use an interactive visualization to see how changes in abiotic factors can affect a marine ecosystem.	5 Minutes
DSJ Modeling Predictions	Students return to their journal to model predictions for two dive sites based on the abiotic data they collected.	5 Minutes
Discussion	Whole class discussion about student observations about the data, making connections and observing patterns across student experiences at different dive sites. This is a primer for lesson 5 where students will collaborate to solidify their hypotheses.	10 Minutes

Potential Discussion Questions:

1. **What differences did you observe in the abiotic data you collected?** *A. Student responses may vary, the main factors that change across dive sites include: water clarity, dissolved oxygen, temperature, and pH.*
2. **How do you predict temperature will impact biotic factors at the different dive sites? Why?** *A. It is difficult for marine organisms to survive when the water is too warm, because warm water contains less dissolved oxygen for organisms to breathe. (BioDive sites: Papua New Guinea)*
3. **How do you predict pH will impact biotic factors at the different dive sites? Why?** *A. It is difficult for living organisms to survive in acidic water (pH below 7), so biodiversity will be reduced. (BioDive sites: Papua New Guinea)*
4. **How do you predict salinity will impact biotic factors at the different dive sites? Why?** *A. Salinity in the ocean ranges between 34 and 36 ppt, and while most organisms have the ability to adapt to some variation, too much change is detrimental to biotic organisms. (BioDive sites: none)*
5. **How do you predict dissolved oxygen will impact biotic factors at the different dive sites? Why?** *A. Increased turbidity blocks the sunlight that plants need to produce oxygen for biotic factors. Floating particles also absorb heat from sunlight and warm the water. (BioDive sites: Las Perlas, Senegal)*
6. **What visible changes to the environment do you predict you'll observe on your dive? Why?** *A. When dissolved oxygen levels drop below 5.0 mg/l, living organisms are put under stress. (BioDive sites: Senegal, Las Perlas)*
7. **What visible changes to the organisms in the environment do you predict you'll observe on your dive? Why?** *A. Students may talk about various changes not explicitly discussed in their DSJ including changes to snails' shells as a result of long term acidity.*

Duration: 45 minutes

Digital Science Journal:

Hypotheses (16)

Comparison (17)

Identifying Patterns (18)

Conclusion (19)

Do More (20)

Virtual Reality:

Dive Sites

NGSS PerformanceExpectations:

Contributes to MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Contributes to MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Contributes to MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Students who demonstrate understanding can:

- Link observations of phenomena to predictions on the impact to the marine ecosystem (Page 16)
- Compare a control and a variable dive site to see link the impacts of abiotic factors to the ecosystem (VR)
- Modify prediction based on new observations and re-evaluate how abiotic factors impact biotic factors in a marine ecosystem (Page 17)
- Analyze patterns of data to compare the impact of abiotic factors (salinity, pH, temperature, water clarity and dissolved oxygen) on marine biodiversity (Page 18)
- Collaborate with peers to collect, analyze, and review patterns in data and write about observed patterns in salinity, temperature, pH, water clarity, and dissolved oxygen across six marine environments. (Page 18)
- Hypothesize the impact of abiotic factors on biotic factors across one marine environment using evidence and reasoning (Page 19)
- Synthesize and communicate findings clearly (Page 19)
- Integrate one action to students everyday lives that will help maintain marine ecosystems (Page 20)

Context for Lesson:

Students connect their observed data and predictions, and work collaboratively to discuss patterns across all dive sites. Students clarify their observations, claims, evidence, and reasoning, and submit their formal hypothesis explaining how the abiotic data they collected affected the biotic variables at their dive sites.

Student Prior Knowledge:

Students should understand how abiotic factors affect biotic factors in marine ecosystems, and that food webs show more connections between organisms than food chains. Students who are struggling can go back to the Abiotic Data page in their journal to explore how changes in specific variables change to the environment to finalize their hypotheses.

Potential Misconceptions:
Students may think that different changes in environment (salinity, pH, temperature, water clarity and dissolved oxygen) all have the same effect: loss of diversity or life in the ecosystem. They can go back to Page 14 to see the individual and different effects that each factor can have on the ecosystem.

Students may struggle to link both biotic and abiotic factors together to make conclusions.

SEP:

Analyzing and interpreting data

Constructing explanations and designing solutions

Engaging in argument from evidence

DCI:

LS2.A: Interdependent Relationships in Ecosystems

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

CCC:

Systems and system models

Stability and change

Influence of engineering, technology, and science on society and the natural world

Activity	Learning Experience	Duration
Direct Instruction	Teachers prime students to recall their abiotic data and their predictions about how abiotic data might impact biotic data. Students will be guided to visit page 18 of their journal to complete their experience.	4 Minutes
DSJ Hypotheses	Students create hypotheses about the impact of abiotic factors on the abiotic organisms at the different dive locations.	5 Minutes
VR Dive Sites	Students visit two different dive sites, observing distinctions in biodiversity and ecosystem health.	5 Minutes (per student)
DSJ Dive Deeper	Protecting our Planet [video], Sea turtles fun facts [video], Goal 14: Life Below Water [article], To Map a Coral Reef, Peel Back the Seawater [article], Ocean Futures: Papua New Guinea [article], Fresh Funds [article]	15 Minutes
DSJ Comparison	After diving at both sites, students make revisions to their models.	3 Minutes
DSJ Identifying Patterns	Students then collaborate to identify patterns in their collected data and observations across six dive sites.	5 Minutes
DSJ Conclusion	Finally students revise formal hypothesis about how abiotic factors impacted biotic factors.	3 Minutes
Discussion	Students share the similarities, differences, and remaining questions about patterns in data. Students may reflect on how the data show the impact of human activity, and how humans could design solutions to adverse impacts.	10 Minutes

Potential Discussion Questions:

1. **How was your prediction different from what you observed on your dive?** *A. Answers may vary, students should confidently use the names of abiotic factors that impacted their specific dive region and discuss how it impacted biotic data.*
2. **What patterns in pH did you observe across dive sites?** *A. Answers may vary, students may suggest the pH impacted the water clarity, the color or health of the coral, or the lack of organisms at one of the dive sites based on their work identifying patterns.*
3. **What patterns in salinity did you observe across dive sites?** *A. Salinity variables did not vary across dive sites.*
4. **What patterns in turbidity/water clarity did you observe across dive sites?** *A. Answers may vary, students may suggest that when the water was not clear, there were changes to the dissolved oxygen or pH variables at that location.*
5. **What patterns in dissolved oxygen did you observe across dive sites?** *A. Answers may vary, students may suggest that changes in dissolved oxygen were associated with changes in turbidity, and there were fewer organisms present.*
6. **Why would industrialization cause soil erosion?** *A. Cutting down trees to build or fuel factories contributes to soil erosion.*
7. **The bleaching of coral is the result of acidification, why would industrialization cause acidification and coral bleaching?** *A. When carbon dioxide dissolves in seawater, the water becomes more acidic. Exhaust and pollution from factories can cause the ocean waters to become more acidic, and erode coral or make it more difficult for coral organisms to grow.*