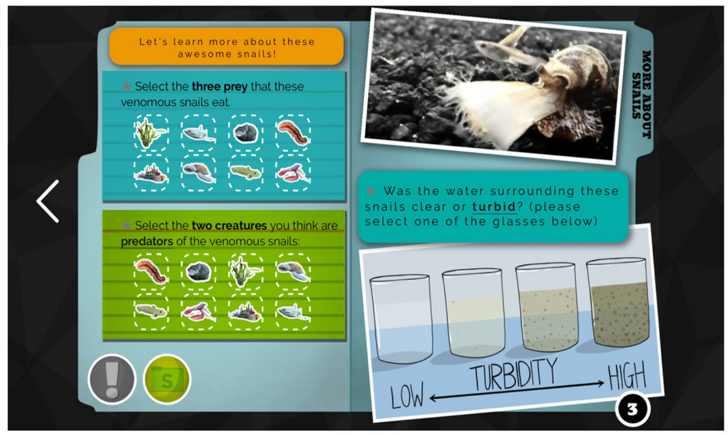
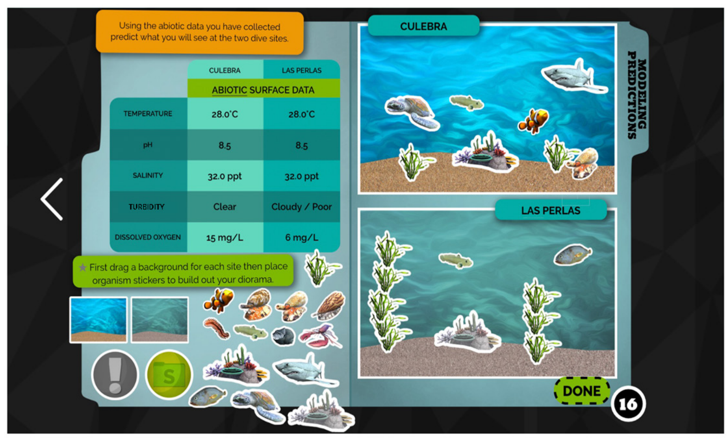
In BioDive, students are marine biologists traveling to international dive sites to study the impact of pollution across three diverse marine ecosystems. This immersive journey begins with a video of venomous marine snails hunting for prey as an anchoring phenomenon to spark curiosity and invite student inquiry. As students move through the experience, they toggle between a personalized website and WebVR (virtual reality on a web browser) expeditions in the field visiting sites in the Eastern Atlantic, Eastern Pacific, or Indo-Pacific. Students make observations, collect data, create and test hypotheses, collaborate with fellow scientists and synthesize their knowledge about the impact of key variables on different ocean ecosystems.

Students dive into the world of venomous marine snails!



Students share their observations of snails in the Digital Science Journal.

Students collect abiotic data at their dive site.



Students predict what they will see at dive sites based on abiotic data.

To begin this journey, you will need access to:

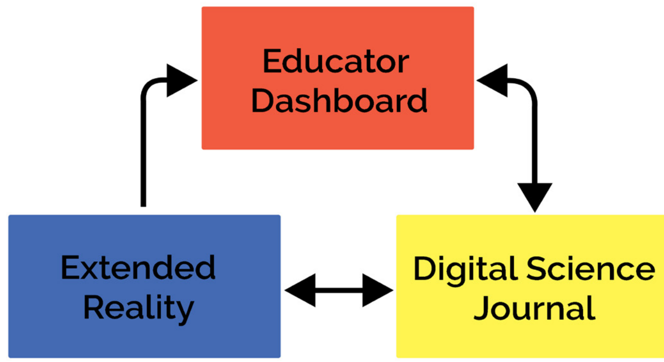
(1) One computer per student (Chromebooks, laptops, desktops): Students will use these devices to log into their individual accounts.
(2) Please be sure your school allows access to the website, https://biodive.killersnails.com/. Share this tech checklist with your team.
(3) Please visit our FAQ for more information, https://biodive.killersnails.com/faq.php
(4) Please feel free to email any other questions to info@killersnails.com

Making a Class:

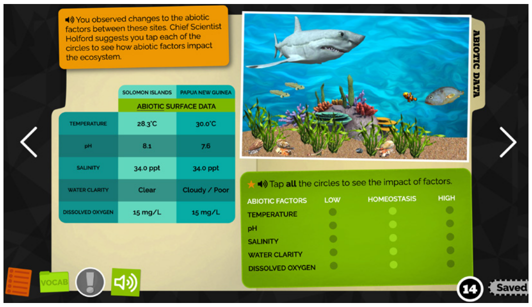
Once logged in from the main menu you will be able to add classes, edit your profile, and manage classes.

Students will log in using an email as a username and a password. You can use Google Classroom or Microsoft to pre-populate the roster of students in each class, upload a CSV with each student's name and unique email address, or manually enter each student's information. We will never email your students or use their email for marketing purposes.

Components of BioDive:



Digital Science Journal (DSJ):



After creating a class, direct your students to https://biodive.killersnails.com/ to have students login with the same information you provided when creating the class.

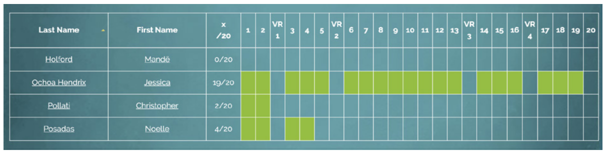
Once logged in, students will enter the Table of Contents (TOC) where they will have access to the Tutorial. When they have completed everything on a page they will be directed to move on to the next page with an arrow on the right. If the arrow has not appeared there may be something left to do on the page. Check for the star icons, if they are grey that task must be completed to move forward. They can also navigate back to a previous page by either tapping the arrow on the left or visiting the TOC.

Extended Reality:

Students will get first person virtual experiences throughout BioDive. In the 4 extended reality scenes students will be prompted to launch the scenes on their web browser within the DSJ. These scenes may take a few seconds to a few minutes to load. A green bar at the bottom of the browser window will indicate the percentage loaded.

Students will navigate the scenes with either their mouse/trackpad or keyboard to look around and holding down on the mouse/trackpad to move forward.

Educator Dashboard:



Last Name	First Name	x /20
Holford	Mondo	0/20
Ochoa Hendrix	Jessica	19/20
Pollati	Christopher	2/20
Posadas	Noelle	4/20

In the Dashboard you can view where your students are in the experience as well as what they have done on each page of their digital science journal.

When looking at the dashboard you can view individual pages done by your students by tapping the green progress boxes. You can also leave your students written feedback as well as stickers when reviewing their progress.

When you leave feedback your students will be notified with a  .

Students can then read your feedback and edit their work.

Lesson 1

Overview:

This lesson introduces students to the BioDive platform. Students watch a video of venomous marine snails hunting for prey, a surprising experience for many! This serves as an anchoring phenomenon to spark interest in these snails, their role in the ecosystem, and real research studying venom to make medicines for people. In a webVR activity, students navigate around the snails' ecosystem to observe them hunting. Students document their observations about the food web in followup activities, and apply these observations as they categorize organisms into consumers and producers, and consider transfer of energy between trophic levels. At the end of this lesson, students will be able to describe predator-prey relationships between venomous snails and other animals in the ecosystem.

Prior Knowledge:

Before beginning this lesson students should know:

- What devices they will be using throughout this experience
- The routine for distributing, logging in, and collecting devices
- How to navigate to https://biodive.killersnails.com, and log in using their username and password

Page	Activity	Total Time: 30 Minutes
1: Tutorial	Sign into the Digital Science Journal (DSJ), learn how to interact with features like the Table of Contents, vocab list, teacher comments, and sound controls	5 minutes
2: Mission Background	Meet Chief Scientist Dr. Mandë Holford, learn about her biomedical research, and observe anchoring phenomenon of snails hunting	5 minutes
webVR: View Hunt	Observe three venomous snails hunting different types of prey	5 minutes
3: More About Snails	Identify the snails' prey and predict their predators. Reflect on observations to identify levels of turbidity in the snails' habitat	1 minute
4: Ecosystem	Respond to questions about the food web	4 minutes
webVR: Start Dive	Observe organisms in a coral reef	5 minutes
5: Trophic Levels	Categorize marine organisms by trophic level	3 minutes
6: Energy Pyramid	Apply the 10% rule to the transfer of energy in an energy pyramid	2 minutes

Potential Discussion Questions:

1. What are observations? Why do you think they are important in science? *Observations are using your senses, or tools to notice things in an environment. Observations are important because they are the first step in developing questions about how systems work.*
2. Why are scientists studying venomous marine snails? *Molecules in their deadly venom can inspire medicines for human diseases.*
3. How can our observations help us protect the snails and help scientists study them to create medicines? *Answers will vary: we could see what snails need to eat to survive, healthy conditions in their habitat.*
4. What do we call the organisms at the bottom of the food web? Where do they get their energy from? *Primary producers. They are plants and algae and get their energy from the sun through the process of photosynthesis.*
5. What do we call organisms that eat primary producers and other organisms in the food web? *Primary consumers eat primary producers. These organisms are also herbivores. Secondary and tertiary consumers eat other consumers.*

Learning Objectives:

After Lesson 1, Students will be able to:

- Describe how venomous marine snails hunt for prey
- Use models to gather information about the flow of energy through an ecosystem and demonstrate understanding of relationships between specific organisms
- Develop models of trophic levels in a marine ecosystem
- Use mathematical representation to show how energy transfers between trophic levels

Overview:

In this lesson, students deepen their understanding of the reef ecosystem where venomous snails are found, measure abiotic data, and begin to explore how biotic and abiotic factors are related. Students build and use models of the food web in this ecosystem, then explore how changes in one trophic level impacts others. The lesson culminates with students virtually visiting a location to gather data, and explaining how differences in abiotic data may impact biotic factors in the reef.

Prior Knowledge:

Before beginning this lesson students should know:

- The content of lesson 1, especially snails' role in the food web
- The concept of trophic levels
- The importance of making observations to help define problems
- Familiarity with abiotic factors like temperature, pH, salinity, turbidity, dissolved oxygen

Page	Activity	Total Time: 40 Minutes
7: Biodiversity	Interact with a model food web, make observations about interdependent relationships among organisms within a food web	5 minutes
8: Build a Model	Design an oceanic food web, predict the impact of changes in the population of organisms in one trophic level on other trophic levels in an ecosystem	10 minutes
9: Seas Under Siege	Learn about Dr. BIG's factories as a source of pollution, then compare changes to biodiversity in the same ecosystem at two points in time	5 minutes
10: Ocean Zones	Classify oceanic zones	5 minutes
11: Abiotic & Biotic	Distinguish between abiotic and biotic variables	3 minutes
12: Dive Equipment	Examine equipment needed to measure abiotic data on a scientific dive expedition	2 minutes
13: Dive Locations	Select the geographic dive location	1 minute
webVR: Boat	Apply knowledge of equipment to collect abiotic data at a dive site	5 minutes
14: Abiotic Data	Explain the impact of the abiotic variables temperature, pH, salinity, turbidity, and dissolved oxygen on biodiversity in a coral reef habitat	4 minutes

Potential Discussion Questions:

1. What happens to the other trophic levels when you remove or reduce the population of organisms in one trophic level? *The number of organisms in the level below will generally increase, and the number of organisms in the level above will generally decrease.*
2. How are abiotic factors different from biotic factors? *Abiotic factors are the nonliving chemical and physical factors that impact ecosystems. Biotic factors are the living components of ecosystems like animals, plants, fungi, and bacteria.*
3. How might temperature impact the marine ecosystem? *Temperature changes greatly impact the distribution of marine life. When the temperature is too warm or too cold, marine organisms are unable to survive and may leave the area if possible.*
4. How might pH impact the marine ecosystem? *The pH is a measurement of how acidic or basic (alkaline) a liquid is. A lower number refers to more acidity. More acidic water harms organisms, for example it weakens the shells of organisms like snails, clams, and oysters.*
5. How might salinity impact the marine ecosystem? *While many organisms can tolerate slight variations in salinity, significant changes can harm ocean life. For example, fish can have trouble swimming, and invertebrates can die.*
6. How might turbidity/water clarity impact the marine ecosystem? *Turbidity or water clarity is a measure of how far the light penetrates the water column. In clearer water, more light can get through. When the water is turbid or there are many particles suspended in the water, it is difficult for producers to receive sunlight to grow and provide energy for the ecosystem.*
7. How might dissolved oxygen impact the marine ecosystem? *Dissolved oxygen is required for respiration in addition to other chemical processes. Pollution leads to lower levels of oxygen and more bacteria in seawater, making it difficult for organisms to breathe and survive.*

Learning Objectives:

After Lesson 2, Students will be able to:

- Represent their ideas using models
- Make predictions about an ecosystem
- Describe the impact that changes to biotic factors in an ecosystem would have on populations in other trophic levels
- Use new vocabulary words to describe marine ecosystems and scientific equipment
- Describe the impact that changes to abiotic factors in an ecosystem would have on populations of organisms there

Overview:

During Lesson 3, students use the abiotic data they have collected to predict what they will see and what the biotic factors are at specific dive sites. They will compare different findings between locations to detect patterns and form hypotheses based on the data, before returning to webVR and observing the sites. The experience ends by supporting their conclusions about the impact of industrial pollution on the sites, and learning about real-world resources related to the United Nations Sustainable Development Goals.

Prior Knowledge:

Before beginning this lesson students should know:

- Industrial pollution changes abiotic factors in marine ecosystems, which can affect biotic factors
- Temperatures may be measured in Celsius
- Lower pH values are more acidic
- Dissolved oxygen values that support ocean life

Page	Activity	Total Time: 30 Minutes
15: Modeling Predictions	Construct a model of two coral reefs using abiotic data. Make inferences about how abiotic variables impacted organisms at two different dive sites	5 minutes
16: Hypothesis	Use vocabulary words to elaborate on predictions	5 minutes
webVR: Dive Sites	Observe one dive site near a potential source of industrial pollution and one far from it to see the impacts of abiotic factors on biotic factors	5 minutes
17: Comparison	Use vocabulary to explain how abiotic factors impact biotic factors in a marine ecosystem and revise predictions based on observations	4 minutes
18: Identifying Patterns	Collaborate with peers to collect, analyze, and review patterns in data. Identify patterns in salinity, temperature, pH, water clarity, and dissolved oxygen across six dive sites	5 minutes
19: Conclusion	Use evidence and reasoning to support a conclusion about the impact of abiotic factors on biotic factors in one location	5 minutes
20: Do More	Connect to real-world resources related to the United Nations Sustainable Development Goals	1 minute

Potential Discussion Questions:

1. How did your predictions differ from what you observed on your dive? *Answers may vary: students should confidently use the names of abiotic factors that different between dive sites in their location, and discuss how those differences affected biotic factors like coral bleaching and biodiversity.*
2. Which abiotic factors affected the locations? Were those differences related to the biotic factors? *Answers may vary: Temperature and pH differed between the sites in the Indo-Pacific location: the site near the factor was warmer and more acidic. Salinity never differed between sites at the same location. Turbidity differed between the sites at all three locations; the site near the factor always had cloudier water. Dissolved oxygen differed between sites in the Eastern Pacific and Eastern Atlantic locations: sites near the factory had less dissolved oxygen. Those differences seem to be related to biotic factors like less biodiversity and coral bleaching at the sites near the factories.*
3. Is there any other information you would want to have to make sense of your data and observations? *Answers may vary: more information about what the industrial pollution is, how much there is, and how often it is released; more detail about the number and type of organisms at each site; more background about the mechanisms for how abiotic factors impact organisms.*

Learning Objectives:

After Lesson 3, Students will be able to:

- Analyze and interpret data to provide evidence for their conclusions
- Revise predictions
- Represent their data and observations using models
- Construct an explanation for differences they observed between dive sites
- Construct an argument supported by empirical evidence that changes to abiotic factors in an ecosystem affect organisms

Middle School NGSS Performance Expectations:

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.

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

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

MS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-ESS3-3 Earth and Human Activity
Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

SEP:

Developing and Using Models

Analyzing and Interpreting Data

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Obtaining, Evaluating and Communicating Information

DCI:

LS2.A: Interdependent Relationships in Ecosystems

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

ESS3.C: Human Impacts on Earth Systems

CCC:

Patterns

Cause and Effect

Structure and Function

Stability and Change

High School NGSS Performance Expectations:

To fully demonstrate NGSS Scientific and Engineering Practices, high school students must go beyond the activities in the BioDive digital science journal. For example, additional use of mathematical representations of the flow of energy and cycling of matter, written work to evaluate claims, evidence, and reasoning for their explanations of relationships between abiotic and biotic factors, and design and evaluate solutions for issues they identify.

HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

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

SEP:

Developing and Using Models

Analyzing and Interpreting Data

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Obtaining, Evaluating and Communicating Information

DCI:

LS2.A: Interdependent Relationships in Ecosystems

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

ESS3.C: Human Impacts on Earth Systems

CCC:

Patterns

Cause and Effect

Structure and Function

Stability and Change