# Invisible Forest Module: Optional It's Only a Drop of Water

Project Based Learning- Systems Extension

**Teacher Guidelines:** This is an optional SYSTEMS extension to the PBL lesson and is very useful in guiding students through modeling, sense-making, seeing the entire system-at-play, and asking questions. It was written based on Ambitious Science Teaching guidelines. For more background information on AST as it relates to this lesson, see Chapters 6 & 7 (pages 111-150) of their book (by Mark Windschitl, Jessica Thompson, and Melissa Braaten). Or if you do not have their book, you can read an older version via PDF.

**An overview of the Phenomenon to start the PBL (see the below "Activity Sequence" section for the specific teaching instructions):**
You will show The Invisible Forest PBL Intro Video from this link or by using this Youtube link.You will also ask the students questions such as these: What happens if the trees are all gone? What happens if the sea level rises so much that we don't have land? What does the ocean give us? (You will not give them the answers at this time, but they will be able to answer these questions at the end of the module. For your reference, here are the short **answers:** 40-50% of Global Oxygen, with 10% coming from heroic "Pro" microbe) (*An alternate video to use as the opening hook is the NOVA program called Earth from Space (https://www.pbs.org/video/nova-earth-space/ from 1h 12 min to 1h 23 min)

This sets the stage and hooks students while getting them to think about big ideas. Students should focus on the idea of *where* our breathable oxygen comes from and on *what* the ocean gives us. The module leads students into asking: How can we measure global Oxygen production? Through PBL students design questions to help guide their curiosity as they move through the module. Through the lessons and activities, the module introduces tools and models to measure and interpret the data collected from the ocean, so that we can begin to understand the rate of oxygen production and changes in the system that could affect global oxygen.

**Objectives:**

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

DCI: ETS1.C: Optimizing the Design Solution
SEP: Constructing Explanations and Designing Solutions

PE: HS-LS1-5.: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms
SEP: Developing and Using Models
CCC: Energy and Matter

**What students learn:**

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Students learn to model a system looking at inputs and outputs of that system. Through the PBL, students learn to design questions to investigate the phenomena more. They learn to evaluate their questions and change their questions based on new information that is presented. In the end, they learn what is in a drop of seawater and how that contributes to our breathable air in the atmosphere, specifically focusing on phytoplankton as the source of that oxygen.

**What students do:**

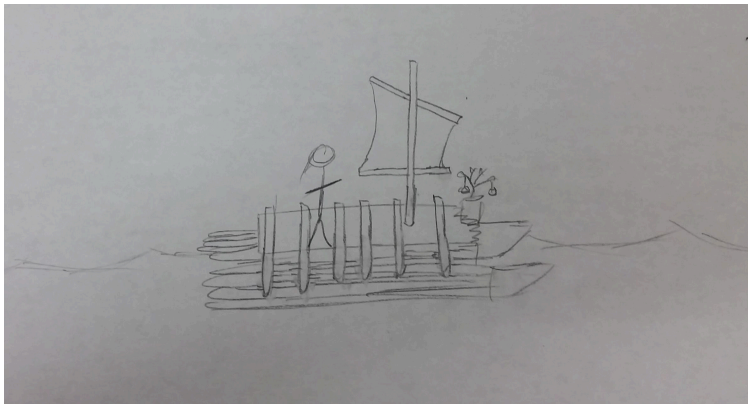
Students design questions to help guide their curiosity as they move through the rest of the module. They focus on their current knowledge and what might be explored as the module develops. Students start by watching a clip from the movie, *Water World*, and discuss what the planet might be like if there was no land and specifically no land plants. They focus on the idea of where our breathable air come from. Through the discussion, the focus turns to what is in the ocean that adds to the atmosphere. In order to self assess their current level of knowledge, they start by doing a pre-assessment demonstrating what is in a drop of ocean water. At the end of each lesson in the module, they reexamine their initial understanding of what is in a drop of seawater and add content they learned within that lesson. At the end of the PBL/module students reflect on what they learned in the module and use that to build a class artistic piece or Public Service Announcement (infographic), focusing on the guiding question, "How can we as citizen scientists, produce a piece of art to educate the public on what is in a drop of water?". How do we make the Invisible Forest visible to others? Their final class art product can then be uploaded to the SEE website for display/showcase with ISB.

**Before Class:** Set up "Water World" video clip [only show up to 1:08 to set the premise]. Have available a whiteboard or post-it board and post-it notes and markers. (If students are familiar with Netlogo software, they can also produce a final diagram as shown in the examples below)

**Activity Sequence:**

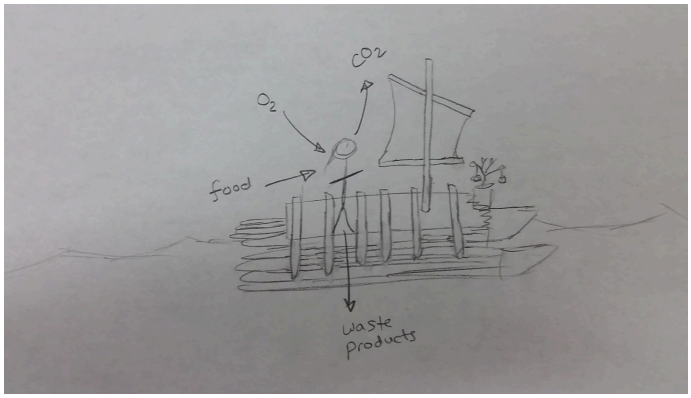
1) Tell students, "We are about to explore a scenario." [Show "Water World" clip]. "How many of you have seen this movie? What is unique about this world seen in the video? What systems are helping the hero of the story survive? [Elicit student ideas.] Yes, the trees are gone from the globe."
2) Ask students, "What do you already know about how this person is surviving?" Tell students, "We are about to begin a diagram (create a model) of what we see in the scene and add all the **inputs** and **outputs** that keep the system going as we think about it as a class." Draw a picture of the hero on his raft, in the middle of the ocean with his lemon tree.

Sample:



3) Next teachers should engage in the Ambitious Science Teacher process by asking the following questions: What will he eat? What else does he need to survive? [prompt if needed-- What will he breathe? What is in the atmosphere that helps him breathe?] Start with a whole class input to the consensus model. See https://ambitiousscienceteaching.org/ for more on the AST Process.

Sample:

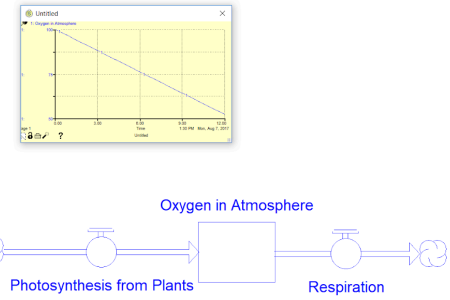


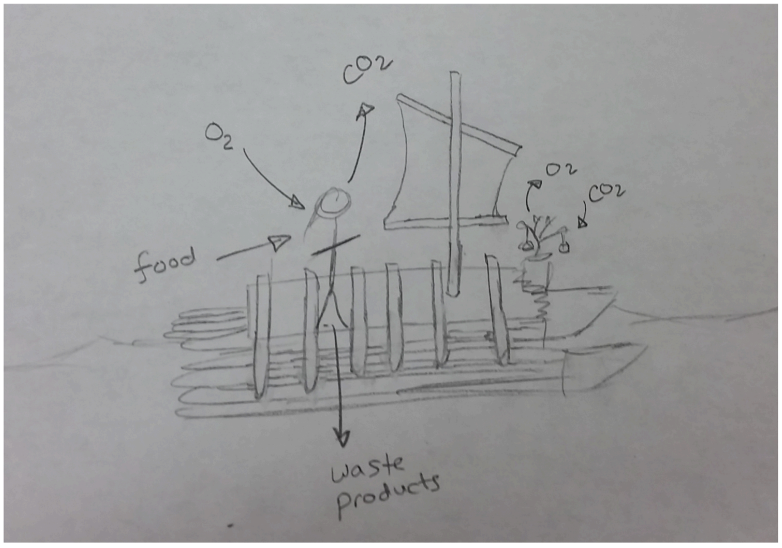

4) The teacher starts drawing and adding to the model of what is seen in the freeze-frame of "Water World." On poster paper or the whiteboard, draw a very basic pictorial representation of the phenomenon that students are exploring. Ask students to copy the diagram as it is made into the lab notebooks so that it is one that the class as a whole "owns."
5) Then, with input from students, add labels on this drawing that indicate students' hypotheses about underlying events or processes that influence the phenomenon. Questions to ask: What phenomenon are we seeing here? What is unique about this world seen in the video? What systems are helping the hero of the story survive?...[elicit student ideas.]... Yes, the trees are gone from the globe. What happens if the trees are all gone? What happens if the sea level rises so much that we don't have land? **What does the ocean give us?**

6) Students should begin to realize the phenomenon as a world without land plants that produce oxygen. And yet, a human is alive. They should, at this point, draw their own diagram of this system and begin generating questions about this system.
7) Next, ask students, What is in a Drop of Seawater? Follow the instructions in the PBL It's only a Drop of Water Lesson.

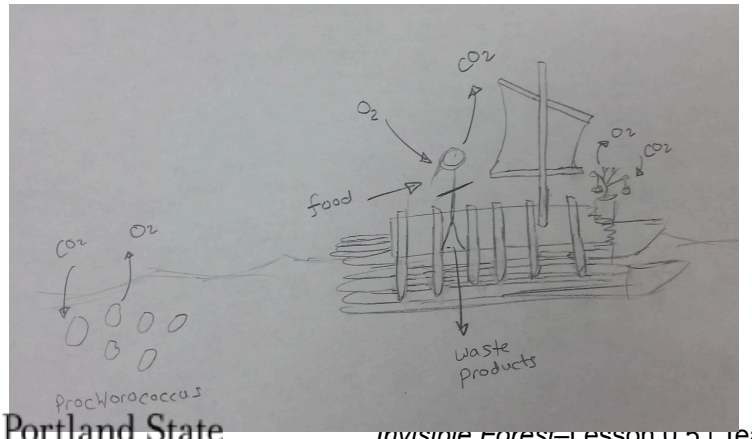
Teachers - Come back to this Lesson Plan after Completing Lesson 1 to revisit models. See below for instructions.

After completing **Lesson 1**, come back to students' models so they can add onto them. The above graph shows the relative amount of oxygen in the atmosphere per the given model, assuming that the person respires oxygen at a faster rate than the little lemon tree.

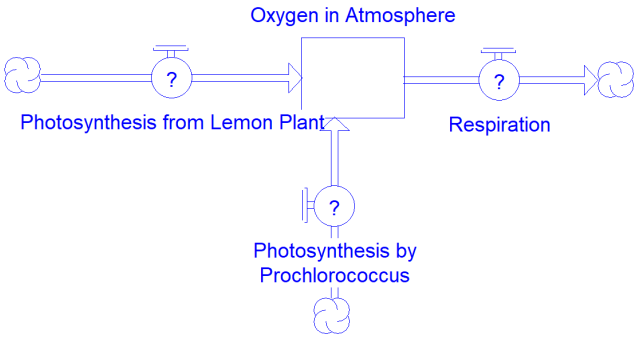



8) Have the students diagram the raft, this time, with the atmosphere -- draw the system that is producing what the hero needs. These are the students' initial hypotheses in diagrammatic form. In upcoming rounds of activities and discussions, students should decide how they want to change the system model. By Lesson 3 they should be able to draw more depth into the system, and add Prochlorococcus (Pro-- that produces 10% of global oxygen). We have

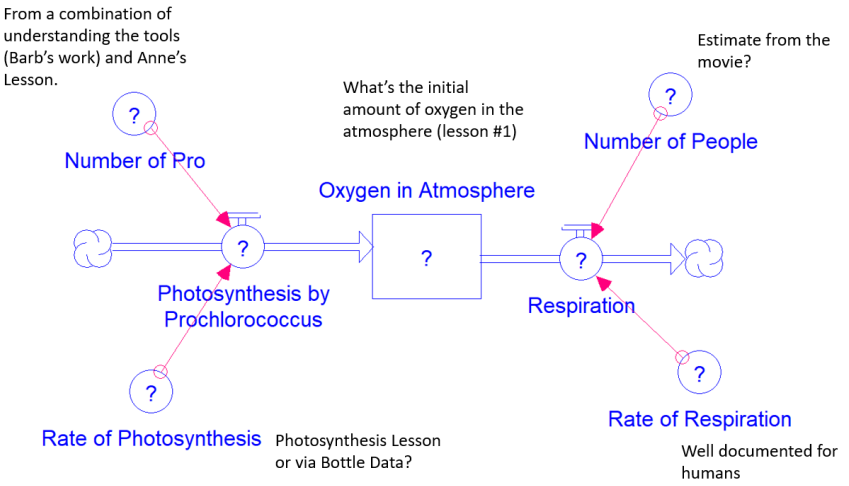


included a sample drawing to the left of this text.




We need to know the relative rates of oxygen production and respiration to know whether the oxygen available to our hero will change over time.

9) a) What amount of oxygen is in the atmosphere? It's only 20% oxygen, is that a problem? Where does oxygen come from on Earth? c) Is there anything missing in our model? d) If trees and plants are gone where is more oxygen going to come from? How much? Is it enough and does it enter at a fast enough rate to keep the atmosphere supplied with oxygen? How can we measure this? What questions do we need to ask to begin to measure the rate, and model what is possible?




10) What tools are available to measure oxygen and what is producing oxygen in the ocean?