STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Welcome to STEAM FORWARD!

Be Water Wise
Career: Engineer
Episode: Life Support Systems

Even though the habitats at Georgia Aquarium hold 10 million gallons of water, the facility itself uses only as much water as an average supermarket!

Ready for more learning surprises? Invite our Life Support Systems team into your classroom and show your students STEAM learning at work. They will see the three different types of filtration systems (mechanical, chemical, and biological) that process more than 90 billion gallons of water a year at Georgia Aquarium.

After observing how 160 sand filters, 75 protein skimmers and 30 ozone contact towers work together to support over 100,000 animals each day, your class will gain a better understanding of the flow of energy and matter in natural ecosystems.

Following the video lead of our Georgia Aquarium Life Support Systems Manager, John Masson, your students will choose an exhibit type and design their own aquatic habitats and filtration systems! Students are encouraged to think beyond the scope of an aquarium setting to imagine other situations where filtration and pump systems are necessary.

THE ESSENTIALS: ASK & ANSWER

- How do organizations like Georgia Aquarium design life support systems to replicate natural filtration processes?
- Why is clean water important to support animal and human life?
- What obstacles and opportunities exist in ensuring all living creatures have access to clean water?

OBJECTIVES: Why are my students learning this?

At the completion of this mini-unit, your students will be able to:

- Explain how water filtration occurs in natural aquatic environments.
- Describe the importance and function of life support systems used by Georgia Aquarium.
- Compare and contrast how water filtration occurs in natural aquatic environments and man-made aquatic environments like the Ocean Voyager habitat at Georgia Aquarium.
- Define mechanical, chemical and biological filtration.
- Evaluate the effectiveness of mechanical, chemical and biological filters using mathematical data.
- Implement the design process to construct an aquarium habitat.

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Using STEAM FORWARD

For this project, you will need to print copies of the Student Activity pages. Students will benefit from having calculators and access to the internet for background research although **internet availability is not necessary**.

Students should work in small groups (2-4) to facilitate collaborative problem solving. Allow students to express their creativity throughout the activities.

To begin STEAM Forward, show your class the video hosted by marine biologist Dr. Mike Heithaus. At the conclusion of the first video segment, groups can work together to complete **Go with the Flow: Energy and Matter in Ecosystems.** Then, the class will reassemble to review their answers or watch the next video segment showing how filtration works followed by the lesson, **Filter it Out!** The final activity, **Make it Work in Your Own Exhibit!,** is an aquatic design challenge.

All three written activities can be completed over one or two typical class periods depending on the level of your students. Each activity can be used as a stand-alone lesson or as part of a wider unit.

A variety of classroom extensions, outlined in **Beneath the Waves**, are available for you to use and share. As each STEAM Forward video is interdisciplinary in nature, Georgia Aquarium encourages you to **Splash It Around!** within your grade level teams to collaborate on project-based learning.

Your students will meet Georgia Aquarium experts in a surprising career-focused Q&A called **In the Field.** For your planning needs, national and local **Middle School Curriculum Standards** are listed by activity and content at the end of these Teacher Instructions.

If you would like to present how you implemented STEAM Forward in your classroom, we want to hear about it! Please contact Georgia Aquarium's Education Department at education@georgiaaquarium.org to share your best practices and offer constructive feedback.

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Activity 1 – Go with the Flow: Energy and Matter in Ecosystems

Video segment: 00:00–02:20

OBJECTIVES: Why are my students learning this?

At the end of this lesson, students will be able to:

- Explain how water filtration occurs in natural aquatic environments.
- Describe the importance and function of life support systems used by Georgia Aquarium.
- Compare and contrast how water filtration occurs in natural aquatic environments verses man-made aquatic environments like Ocean Voyager.

Introduction

Before students are ready to design their own habitat for ocean creatures they need to start, as any good STEAM expert does, with critical background research. Students will first explore the flow of energy and matter in ecosystems. Then, they will compare and contrast how water filtration occurs in a natural environment versus one that is found in a man-made environment such as the Ocean Voyager habitat at Georgia Aquarium.

Answer Key

1. Using your knowledge and background research, draw a diagram of the flow of energy, phosphorus, and waste products in an open ocean ecosystem that includes whale sharks and dolphins (Don't forget the phytoplankton!). Include what happens to organisms that die without being eaten and to the waste products of those organisms.

   Sketches will vary. Key points that students should have in their diagrams include:
   a. Energy starting at the sun and flowing into phytoplankton and up food chain; dead material being buried or eaten by scavengers/decomposers
   b. Phosphorus being excreted by animals (possibly flowing in from rivers) and being taken up by phytoplankton or plants
   c. Waste building up in sediment, taken out by filter feeders, or eaten by scavengers

2. Describe what happens to waste products and phosphorus in the open ocean.

   Answers should include burial in sediment and phosphorus being used by producers. Students may also include waste being taken out of the water by filter feeders or deposit feeders (like snails).

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

3. Draw a diagram of the flow of energy, phosphorus and waste products in Georgia Aquarium's Ocean Voyager habitat. Be sure to include what happens to organisms that die without being eaten and to the waste products of those organisms.

   Sketches will vary. Key points that students should have in their diagrams include:
   a. Energy come from food placed in tank
   b. Phosphorus excreted by animals; maybe used by algae, or taken out by filters
   c. Waste removed by filters

4. In the video segment, Dr. Heithaus explains the ways that nature takes care of waste in an ecosystem, including filter feeders, decomposers, and wetlands. How does the flow of energy, phosphorus and waste differ between the natural oceans and the Ocean Voyager habitat?

   Students should point out that humans need to be involved in waste removal and providing food in Ocean Voyager.

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Activity 2 – Filter It Out!

Video segment: 02:20–05:27

OBJECTIVES: Why are my students learning this?

At the end of this lesson, students will be able to

- Define mechanical, chemical and biological filtration.
- Evaluate the effectiveness of mechanical, chemical and biological filters using mathematical data.

Introduction

Now that students have learned about the flow of energy and matter in ecosystems and the importance of filtration systems in both natural and man-made environments, they need to understand how three different types of filtration work. This activity dives into chemical, mechanical and biological filtration and walks students through the mathematical calculations for how these systems work.

Answer Key

Sand Filter: Mechanical Filtration

Sand filters physically trap solid wastes as water flows through the filter. In the video, you see Dr. Heithaus help clean out one of the 160 sand filters at Georgia Aquarium. This is an example of mechanical filtration.

1. Using the table below, calculate the amount of water filtered per day at five different flow rates.

Gallons per minute x 60 minutes x 24 hours each day = Gallons per day

Table 2.1. The effectiveness of sand filters at removing large waste particles.

Flow Rate (gallons per minute per square foot of filter)	Proportion of large particles removed	Amount of water filtered per day (gallons)
4	97	5,760
8	96	11,520
12	95	17,280
16	60	23,040
20	20	28,800

2. Use the data in the first two columns to make a graph of the proportion of large particulate matter removed from the water. Be sure to label both axes. Title your graph: *Figure 2.1. Influence of flow rate on the proportion of waste removed by a sand filter.*

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

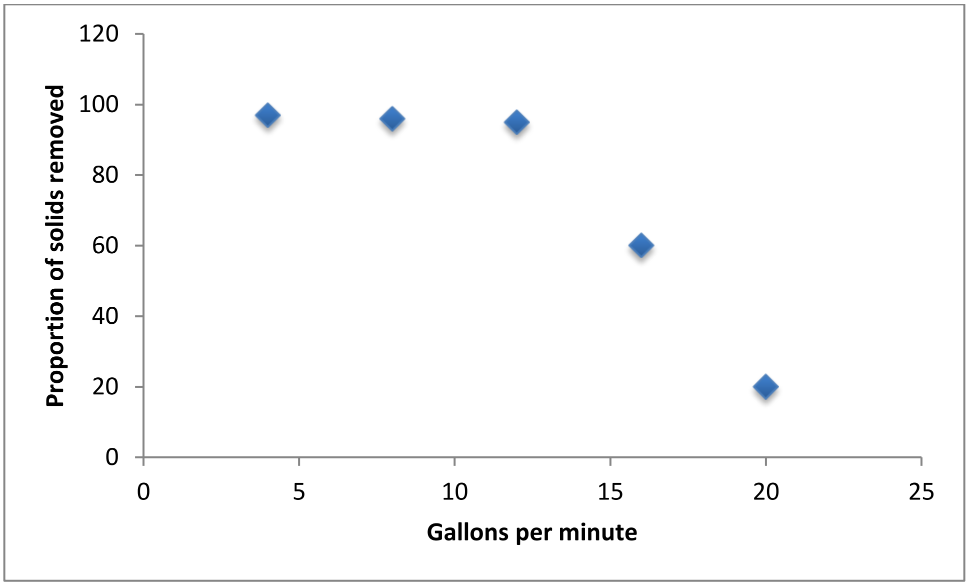


Figure 2.1. Influence of flow rate on the proportion of waste removed by a sand filter.

3. If you are trying to optimize the amount of large particles of solid waste removed from the water, but not buy too many filters, which flow rate should you use? Support your answer with your graph and the calculations you made in your table.

12 gpm (gallons per minute) is the best flow rate to select.

a. Graphs show that if you filter fewer gallons per minute (up until 12 gallons per minute), the filtration effectively removes a higher percentage of waste than if you filter above 12 gallons per minute.
b. At higher flow rates, more water passes through the filter, but you remove less waste.

***Deeper Dive**: Why do you think water filtration is less efficient when the water flow is faster?*

4. The sand filters you are going to use for your design challenge have a surface area of 60 square feet. What is the optimal amount of water filtered per minute for a filter this size? Show your work.

12 gallons per minute per square foot x 60 square feet = 720 gpm per filter.

***Deeper Dive**: Calculate how much water would be filtered per minute for filters of different sizes.*

.

Protein Skimmer: Chemical Filtration

Protein skimmers use chemical filtration to draw out small compounds from the water (that would not be captured in a sand filter) and force them onto surface bubbles. These bubbles form foam that can be collected and removed. Some of the compounds that are collected include proteins, amino acids, fats/oils, bacteria, carbohydrates, metals, salts, and waste products/detritus. The 75 protein skimmers at Georgia Aquarium work by injecting just the right amount of air into the water flowing through it.

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

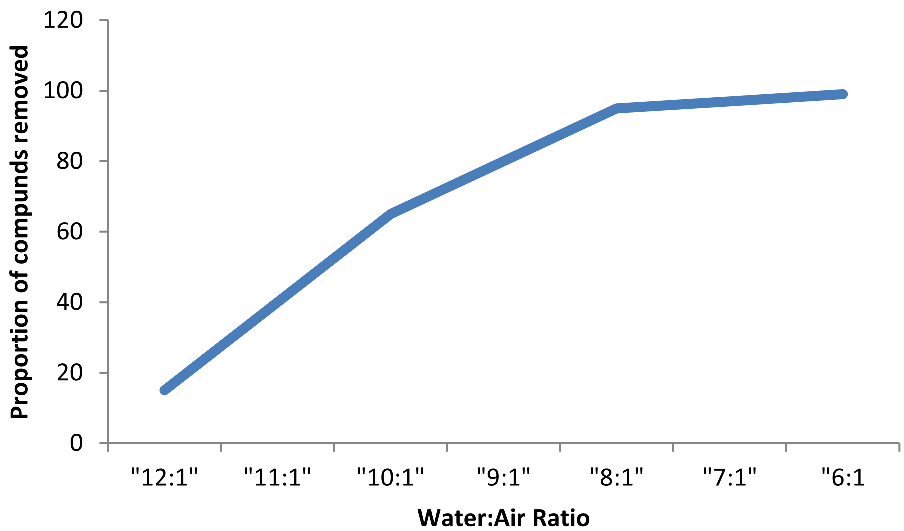


Figure 2.2. Proportion of compounds removed from water passing through a protein skimmer at different water to air ratios.

5. Based on the data in Figure 2.2, what is the best water to air ratio for protein skimmers? Consider that it takes both money and energy to inject air into the water.

   8:1 or above. 8:1 is optimal to avoid the extra cost of injecting additional air for relatively little gain in filtration efficiency

6. If you have a protein skimmer with 800 gallons of water passing through it every minute, how much air needs to be injected each minute for it to work efficiently?

   100 gallons of air per minute because it preserves the 8:1 water: air ratio although gallons are rarely used to measure gas flow. The standard unit for gas is cubic feet. 100 gallons to cubic feet would be 13.4 cubic feet of air per minute for 800 gallons of water. 800 gallons/7.48 gallons per cubic foot = 107cubic feet. 100 gallons of air/7.48gallons per cubic foot = 13. 107/13 = 8 (if rounded to the nearest whole number).

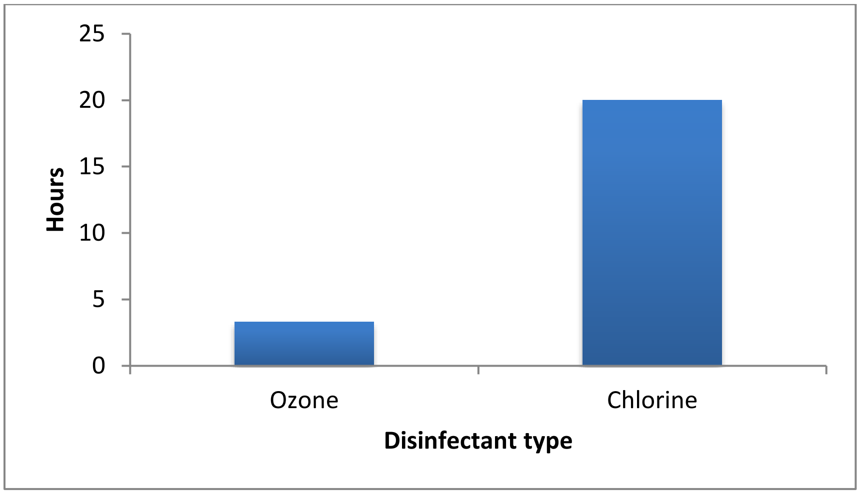
Ozone Contact Tower: Chemical Filtration
Ozone contact towers, another kind of chemical filter, inject ozone gas (O_3) into the water. This gas is very reactive and chemically breaks down organic compounds like harmful pathogens and waste products that are then removed with additional filtration. The key to ozone doing its job is the amount of time it is in contact with pathogens or waste products. The chemical Chlorine is another disinfectant often used to clean water. Which method is faster?

Table 2.3. Time required to achieve a 99.9% disinfection rate

Disinfectant type	Time (hours)
Ozone	3.3 hrs.
Chlorine	20 hrs.

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

7. Use the table above to create a bar graph of the time required to disinfect water.



8. Which disinfectant would be best at the Aquarium? Why?

Ozone is a more effective disinfectant because it takes less time to achieve 99.9% effectiveness

Deaeration Tower: Biological Filtration

At Georgia Aquarium, 40 deaeration towers remove gasses from the water and use biological filtration before sending water back to the exhibit. Water flows through beneficial bacteria that convert ammonia (NH_3) which is toxic to fish into non-toxic nitrate. This process is critical for keeping the water clear and the water quality high. Figuring out how much water to move through deaeration towers is similar to calculating for sand filters. The best rate is 15 gallons per minute per square foot of filter.

9. Calculate the amount of water that the two deaeration tower setups (shown on the Student Activity page) can filter each day. Remember, the area of a circle is pi x r^2. Calculate the area of circles to the nearest square foot.

A) Radius of each circle = 2
Area of each circle = 13 sq. ft. x 15 gallons per minute = 195 gpm per filter = 390 gpm total
Multiply by 60 minutes per hour and then by 24 hours per day = **561,600 square feet**

B) Radius of each circle = 4
Area of each circle = 50 sq. ft. x 15 gallons per minute = 750 gpm
Multiple by 60 minutes per hour and then by 24 hours per day = **1,080,000 square feet**

10. Which sized diameter filter is best, assuming it fits the space you are designing?

The 8' diameter/4' radius filter is better if it fits in the space for which you are designing.

***Deeper Dive**: Explore how the area of a circle scales with its diameter or radius. Ask students if it is better to buy two 8" pizzas or one 16" pizza!*

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Activity 3 – Make it Work in Your Own Exhibit!

Video Segment: 05:30-07:44

OBJECTIVES: Why are my students learning this?

At the end of this design challenge, students will be able to

- Implement the design process to construct a habitat.
- Evaluate the effectiveness of their own habitat and that of their peers and incorporate feedback to iterate and improve effectiveness.

Introduction:

Now it's time for your students to design their own aquarium exhibits based on what they have learned! Interested students can take this challenge further by testing actual filtration systems, just like the architects, designers, engineers, technicians, and construction workers do in the video. It is recommended that students draw a conceptual sketch of their habitat before they complete the quantitative activities in order to determine their filtration needs.

Answer Key

Step 1: Choose your exhibit. Students can build a coral reef, create an open-ocean habitat, develop a kelp forest, or establish a sea turtle pool for injured turtles. Circle or highlight the exhibit selected and use this information for the remainder of the design project.

***Deeper Dive**:* Complete the following steps for all four of the exhibit types.

Table 3.1. Aquatic life living in each exhibit

Exhibit type	Aquatic life living in your exhibit
Coral Reef	1 reef, 500 small fish, 100 medium fish, 500 large fish, 100 snails
Open Ocean	2 whale sharks, 5 manta rays, 50 jacks, 1000 small fish
Kelp Forest	40 kelp stalks, 20 garibaldi, 10 rockfish, 2 wolf eels, 2 octopus
Sea Turtle Pool	10 sea turtles, 500 small fish, 1 oyster bed

Step 2: How much water is in your exhibit?

1. Complete the table below to fill your exhibit with the appropriate amount of water.
   Hint: 1 cubic foot of water = 7.48 gallons.

Table 3.2. Sizes of each exhibit

	Width (feet)	Length (feet)	Depth (feet)	Cubic feet	Gallons
Coral Reef	25	40	20	20,000	149,600
Open Ocean	75	300	30	675,000	5,062,500
Kelp Forest	25	30	30	22,500	168,300
Sea Turtle Pool	40	50	15	30,000	225,000

Cubic feet = width x length x depth
Gallons = cubic feet x 7.48

GEORGIA AQUARIUM

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Step 3: How many filters will you need?

2. For your exhibit, complete the corresponding table to design your filtration system. Each student or team must fill in the missing data for the table corresponding to the exhibit or exhibits they are proposing.

- *Hint 1: To calculate the minimum number of filters of each type for an exhibit, the total amount of water that needs to be filtered in a day (calculated in Table 3.2) should be divided by the per unit rate. The result should be rounded up to the nearest whole number.*

- *Hint 2: Ozone towers need to treat 20% of the total flow through the exhibit.*

*Table 3.3. Minimum needs for the **Coral Reef** exhibit*

Equipment Type	Size (square feet)	Flow rate per unit (gallons per minute)	Minimum # of filters for exhibit	Total gallons per minute
Pumps		**650 gpm**	**4**	2,600 gpm
Sand Filters	**20 sq. ft.**	240 gpm	8	**1,920 gpm**
Protein Skimmers		**340 gpm**	2	680 gpm
Deaeration Towers	173 sq. ft.	2,600 gpm	**1**	2,600 gpm
Ozone Contact Towers			**1**	520 gpm

*Table 3.4. Minimum needs for the **Open Ocean** exhibit*

Equipment Type	Size (square feet)	Flow rate per unit (gallons per minute)	Minimum # of filters for exhibit	Total gallons per minute
Pumps		**2,197 gpm**	**40**	87,880 gpm
Sand Filters	**100 sq. ft.**	1,200 gpm	55	**66,000 gpm**
Protein Skimmers		**1,094 gpm**	20	21,880 gpm
Deaeration Towers	5,859 sq. ft.	87,880 gpm	**1**	87,880 gpm
Ozone Contact Towers			**1**	1,759 gpm

*Table 3.5. Minimum needs for the **Kelp Forest** exhibit*

Equipment Type	Size (square feet)	Flow rate per unit (gallons per minute)	Minimum # of filters for exhibit	Total gallons per minute
Pumps		**584 gpm**	5	2,920 gpm
Sand Filters	**20 sq. ft.**	240 gpm	9	**2,160 gpm**
Protein Skimmers		**380 gpm**	2	760 gpm
Deaeration Towers	195 sq. ft.	2,920 gpm	**1**	2,920 gpm
Ozone Contact Towers			**1**	584 gpm

*Table 3.6. Minimum needs for the **Sea Turtle Pool** exhibit*

Equipment Type	**Size (square feet)**	**Flow rate per unit (gallons per minute)**	**Minimum # of filters for exhibit**	**Total gallons per minute**
Pumps		**2,197 gpm**	**5**	10,984 gpm
Sand Filters	**100 sq. ft.**	1,177 gpm	7	**8,239 gpm**
Protein Skimmers		**305 gpm**	8	2,745 gpm
Deaeration Towers	732	10,984 gpm	**1**	10,984 gpm
Ozone Contact Towers			**1**	2,197 gpm

3. How many times per day is all of the water in your exhibit treated? Would you use the minimum amount of pumps and filters? Why or why not?

Students first need to convert their “total gallons per minute” number into “total gallons per day” by multiplying by 60 and then by 24. Next, students will divide tank volumes into how much water their systems flow per day to find out how many times per day all of the water is treated.

Students should say that, space permitting, they would use more than the minimum number of filters for the exhibit in case one of the filters broke.

Step 4: Students will use the space on the Student Activity page to design a habitat. Students should label all of the components and make sure they have the right numbers for each. Also, their exhibit should be comfortable for guests and easy to maintain for the team behind the scenes. A legend should be included and the habitat drawn to scale.

Now that students have done the math, the sky is the limit for design! They can use grid paper to draw their habitats or access Computer-Aided Design (CAD) software. See below for suggested materials for those students who wish to prototype their habitats. Refer back to the diagram in the video for an excellent review of this process.

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

If students would like to build actual filters, recommended supplies include the following:

- 5-gallon paint bucket
- Powerbuilt 5-gallon level bucket pump
- Watts 3/8-inch x 10 foot clear PVC tubing
- Quickrete 50 lb. all-purpose gravel
- Quickrete 50 lb. all-purpose play sand
- PVC piping
- 20-gallon home aquarium

If students would like to prototype their habitats, recommended supplies include - but are not limited to - the following:

- Plastic cups
- Felt
- Construction paper
- Bubble wrap
- Aluminum foil
- Cotton balls
- Craft sticks
- Glue
- Markers
- Cardboard boxes
- Soda cans
- Pipe cleaners

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Beneath the Waves: Classroom Extensions

- Have students identify areas in the natural or man-made world where the following processes are taking place:
    - Biological filtration
    - Chemical filtration
    - Mechanical filtration

- Present "what-if" questions to students to reinforce the data from their graphs. For example, "If you are running an exhibit and there is a lot of large waste material building up, what kind of filter would you add? Why?"

- What would happen to ecosystems if filter feeders disappeared?
    - Have students investigate what happened to Lake Erie when a new filter feeder was introduced. After zebra mussels populated the lake, they successfully removed large particles from the water and, as a result, the lake became much clearer. Zebra mussels have been detrimental to the lake overall (students can research to find out why), but this example shows how filter feeders function in biological filtration.

- Dead zones
    - What are dead zones?
    - Why do dead zones form?
        - Walk through the steps that lead to dead zones with the class (nutrients allow phytoplankton populations to explode → there aren't enough grazers to eat the phytoplankton → phytoplankton die and decompose → the decomposition consumes too much oxygen → without enough oxygen in the water, organisms die or leave).
        - How could you stop a dead zone from forming?
        - Research red tide and other toxic algae that can form large blooms that are harmful to the environment. Have students investigate why these blooms form and what people can do to stop them from happening. Encourage students to investigate current occurrences of red tide in Florida and Texas and what the environmental effects of algae blooms are on those ecosystems.
    - Phytoplankton and plants in coastal wetlands both absorb phosphorus. When phytoplankton get too much phosphorus, the ecosystem suffers. This is not the case in wetlands. Why?
        - Students should discuss how quickly phytoplankton and algae grow and die, which is why they can choke waterways. However, in marshes and mangrove forests dead material is buried and becomes soil. This can even link to discussions of climate change. The carbon that is captured in the bodies of plants is buried, keeping it from being released as carbon dioxide during decomposition.

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Splash It Around! Use these inquiry-based interdisciplinary activities and project ideas to incorporate our video series into additional classes and content areas.

- Environmental Science
    - Have students research the animals they chose to place in their habitats. What are key facts about these animals? Why is this habitat best for their survival?
    - If they were going to design a more complete ecosystem for the habitat they selected, what organisms would they put in the exhibit? What are the roles of these organisms (predator, herbivore, producer, decomposer)?
    - Why are bacteria important to ecosystems?
    - Why does the Ocean Voyager exhibit at Georgia Aquarium need to be so big?

- Language Arts
    - Have students consider the narrative for their exhibit. Who is the intended audience (age, gender, demographic, prior knowledge) and what literary devices should they use to tell their story? What imagery and language will be most compelling? What might a docent say if they were interpreting this exhibit for their guests? What would they name their exhibit, and for what reasons? If they had to advertise their exhibit in the body of a tweet, what would they say in 140 characters?
    - Revisit the Essential Questions for this episode. Have students write their answers in paragraph form and then discuss their responses in pairs or as a group.

- Economics
    - How much does your habitat cost to build? Research and develop a working economic development plan. Use Georgia Aquarium as a model.

- Social Studies
    - What laws are in place to protect animals in their natural habitats and in human care? What are ways students can advocate for the animals in the habitat they designed? Do these animals face any threats and if so, how can your students take action to help?

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

In The Field

What better way to bring STEAM FORWARD alive for your students then to introduce them to experts at Georgia Aquarium? Here, they will learn more about the background and experience it takes to be a member of the STEAM TEAM. Let's get up close and personal!

MEET: JOHN DAVID MASSON
Manager, Life Support Systems
University of Georgia
Major: Geology

What is the most exciting part of your job with Georgia Aquarium? Designing animal life support systems and seeing them turn into reality. It's always a good feeling when you do the math, draw out the design, purchase the equipment, coordinate construction/installation and watch your design grow and work (hopefully).

What advice do you have for students interested in doing what you do? Stay passionate about learning, focus on what you love and what makes you happy. "If you love your work you will never work a day in your life".

What is something surprising or unexpected about your career path? I was going to go into the oil or mining industry, as I always found earth history and geology fascinating. But the hobby I loved that put me through college gave me a career opportunity that I couldn't pass up. Science, Math, Conservation, the Ocean and my interest in animals - all in one.

What do you say to students who ask "Why am I learning this?" To be and get better. It's not enough to glide through life. If you can be better, why not get better? You never know when this will come in handy. After all, no one would have expected a Geologist to be surrounded by fish and piping but here I am!

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Curriculum Standards

Grades 6 – 8

We know how important it is to be able to document how you spend instructional time in your classroom. To that end, the activities in our STEAM FORWARD curriculum are directly connected to the Georgia Performance Standards and the Georgia Standards of Excellence along with the Common Core State Standards for Mathematics and English Language Arts and the Next Generation Science Standards. To assist with your planning needs, these correlations are organized by activity and content. In the charts below, you can readily see how they fit into your required curriculum. Dive right in!

For All Activities in Episode 1

Georgia Performance Standards for Science	**S6/7/8CS5.** Students will use the ideas of system, model, change and scale in exploring scientific and technological matters **S6/7/8CS6.** Students will communicate scientific ideas and activities clearly. **S6E3**. Students will recognize the significant role of water in earth processes. **S7L4**. Students will examine the dependence of organisms on one another and their environments.
Georgia Standards of Excellence for Mathematics and Language Arts	**ELAGSEL6-8RST7.** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **ELAGSE8SL4.** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. **MP 2.** Reason abstractly and quantitatively.
Common Core State Standards for Mathematics and Language Arts	**RST.6-8.7**: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed through visuals (model, graph, diagram). **SL.8.4**: Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence and sound valid reasoning. **MP.2**: Reason abstractly and quantitatively.
Next Generation Science Standards	**MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services, including water purification. **MS-ETS1-1**. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment.

Activity 1 – Go with the Flow: Energy and Matter in Ecosystems

Georgia Performance Standards for Science	**S6/7/8CS6.** Students will communicate scientific ideas and activities clearly. **S6E3**. Students will recognize the significant role of water in earth processes. **S7L4**. Students will examine the dependence of organisms on one another and their environments.
Georgia Standards of Excellence for Mathematics and Language Arts	**ELAGSEL6-8RST7.** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
Common Core State Standards for Mathematics and	**RST.6-8.7**: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed through visuals (model, graph, diagram).

STEAM FORWARD – EPISODE 5
Life Support Systems [Teacher Version]

Language Arts	
Next Generation Science Standards	**MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services, including water purification.

Activity 2 – Filter It Out!

Georgia Performance Standards for Science	**S6E3**. Students will recognize the significant role of water in earth processes. **S7L4**. Students will examine the dependence of organisms on one another and their environments.
Georgia Standards of Excellence for Mathematics and Language Arts	**ELAGSEL6-8RST7.** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **ELAGSE8SL4.** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. **MP 2.** Reason abstractly and quantitatively.
Common Core State Standards for Mathematics and Language Arts	**RST.6-8.7**: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed through visuals (model, graph, diagram). **SL.8.4**: Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning. **MP.2**: Reason abstractly and quantitatively.
Next Generation Science Standards	**MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services, including water purification.

Activity 3 – Make it Work in Your Own Exhibit

Georgia Performance Standards for Science	**S6/7/8CS5.** Students will use the ideas of system, model, change and scale in exploring scientific and technological matters. **S6/7/8CS6.** Students will communicate scientific ideas and activities clearly. **S6E3**. Students will recognize the significant role of water in earth processes. **S7L4**. Students will examine the dependence of organisms on one another and their environments.
Georgia Standards of Excellence for Mathematics and Language Arts	**ELAGSEL6-8RST7.** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **ELAGSE8SL4.** Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. **MP 2.** Reason abstractly and quantitatively.
Common Core State Standards for Mathematics and Language Arts	**RST.6-8.7**: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed through visuals (model, graph, diagram). **SL.8.4**: Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence and sound valid reasoning. **MP.2**: Reason abstractly and quantitatively.
Next Generation Science Standards	**MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services, including water purification. **MS-ETS1-1**. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment.