

From *Here to There*

with

Woodchip

Bioreactors

Student Investigation Notebook



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Students,

As with any hands-on science experiences, you should observe all appropriate safety guidelines, whether explicitly mentioned in this booklet, or not. Carefully listen to your teacher and follow all safety rules they might require you to follow.

GETTING TO KNOW THE GULF DEAD ZONE



Module 1, Activity #1

Students will...

- ...obtain and evaluate information from a variety of sources.
- ...write, categorize and prioritize questions generated by themselves and other class members.
- ...ensure questions developed relate directly to the phenomenon.

Questions you have...

HELLO, MY NAME IS: NITROGEN

Module 1, Activity #2

Students will...

- ...explain where nitrogen is found on Earth and that nitrogen cycles indefinitely through the Earth system.
- ...learn that the cycle is nonlinear traveling between living things and the physical environment.

THE NITROGEN CYCLE GAME

- 1) Write your starting location in the table below.
- 2) Roll the die to find out where to go next.
- 3) Record HOW you traveled from one location to the next.
- 4) Record WHERE you traveled next.
- 5) Move to your next station.
- 6) Go to #2 and repeat for 50 rolls of your die.

In this game you are a nitrogen atom. You are going to travel the nitrogen cycle stopping in many exciting locations - some of which you probably never have been to before.

For each stop along your journey, remember to record where you went and how you got there (what happens?).

Roll #	Where I am	What happens	Where I'm going
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Roll #	Where I am	What happens	Where I'm going
11			
12			
13			
14			
15			
16			
17			
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19			
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22			
23			
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49			
50			

SORTING OUT THE NITROGEN CYCLE



Module 1, Activity #3

Students will...

- ...create a visual model of the nitrogen cycle.
- ...begin to develop an understanding of how nitrogen is transformed through natural processes.

Draw your initial model here:

WHAT'S IN MY WATER?

Module 2, Activity #4

Water Quality Mini-investigation

Students will...

- ...explore parameters concerning water quality from different sources.
- ...practice analytical skills when accurately collecting data.
- ...analyze and interpret data obtained to determine overall quality of water samples.

Water quality data table:

Water sources →						
Characteristics Measured ↓						

1) Analyze your findings against the EPA's acceptable limits for the characteristics you tested.

2) Discuss why the different water quality parameters being tested are important.

EPA Guidelines link: https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf

BIOREACTOR MATERIALS RESEARCH

Module 2, Activity #5

Students will...

- ...obtain, evaluate and communicate information about the basic properties of various materials and potential usefulness as a substrate in a denitrifying bioreactor.
- ...begin to develop an understanding of what criteria are necessary for materials to serve as substrates in denitrifying bioreactors.

Material	Physical Characteristics		What is the material made of?	Do you think it contains carbon in a useable form?	Would this make a good material to use in a denitrifying bioreactor?
	Surface texture	Density (1=low density, 5=high density)			
Cedar mulch					
Ceramic rings					
Activated carbon					
Plastic "bioballs"					
Rubber mulch					
Used wood mulch					

Consider the following questions:

- 1) Which materials contain carbon that could serve as a food source for bacteria?
- 2) Do any of the materials have surfaces that might be preferred by bacteria?
- 3) What additional questions do you have as you consider these possible materials for use in denitrifying bioreactors?

DENITRIFYING BIOREACTOR EXPERIMENT

Module 2, Activity #6

Students will...

- ...plan an investigation which is valid and addresses issues raised as part of the anchor phenomenon.
- ...analyze and interpret data collected during the investigation.
- ...communicate findings to classmates in appropriate ways.

HYPOTHESIS

What is the hypothesis? (If ____ [IV], then ____ [DV].)

PREDICTION

How will the data look if the hypothesis is supported?

How will the data look if the hypothesis is not supported?

CONSTANTS

What parts of the experiment will be kept the same to prevent affecting the outcome?

DESIGN BASICS

Question:

What is this about?

What is the dependent variable [DV]?

What affects the dependent variable?

From the list above, circle your chosen independent variable [IV].

What is the control group?

What is the experimental group?

DESIGNING SOLUTIONS

How might the results of this experiment positively influence those around you and/or solve a problem?

RESULTS

What claim(s) can you make? *Support each claim with evidence from your experiment.*

In what ways was this experiment valid?

COMMUNICATING INFORMATION

How has your interaction with the scientific community (other students, teachers, experts and other resources) ensured the validity and confirmed the accuracy of this experiment?

SCIENTIFIC ARGUMENT

Write a brief scientific argument. *Your paragraph should include WHAT you think and WHY you think it.*

DNA ANALYSIS OF BIOREACTOR MICROBE ECOSYSTEMS

Module 2, Activity #7

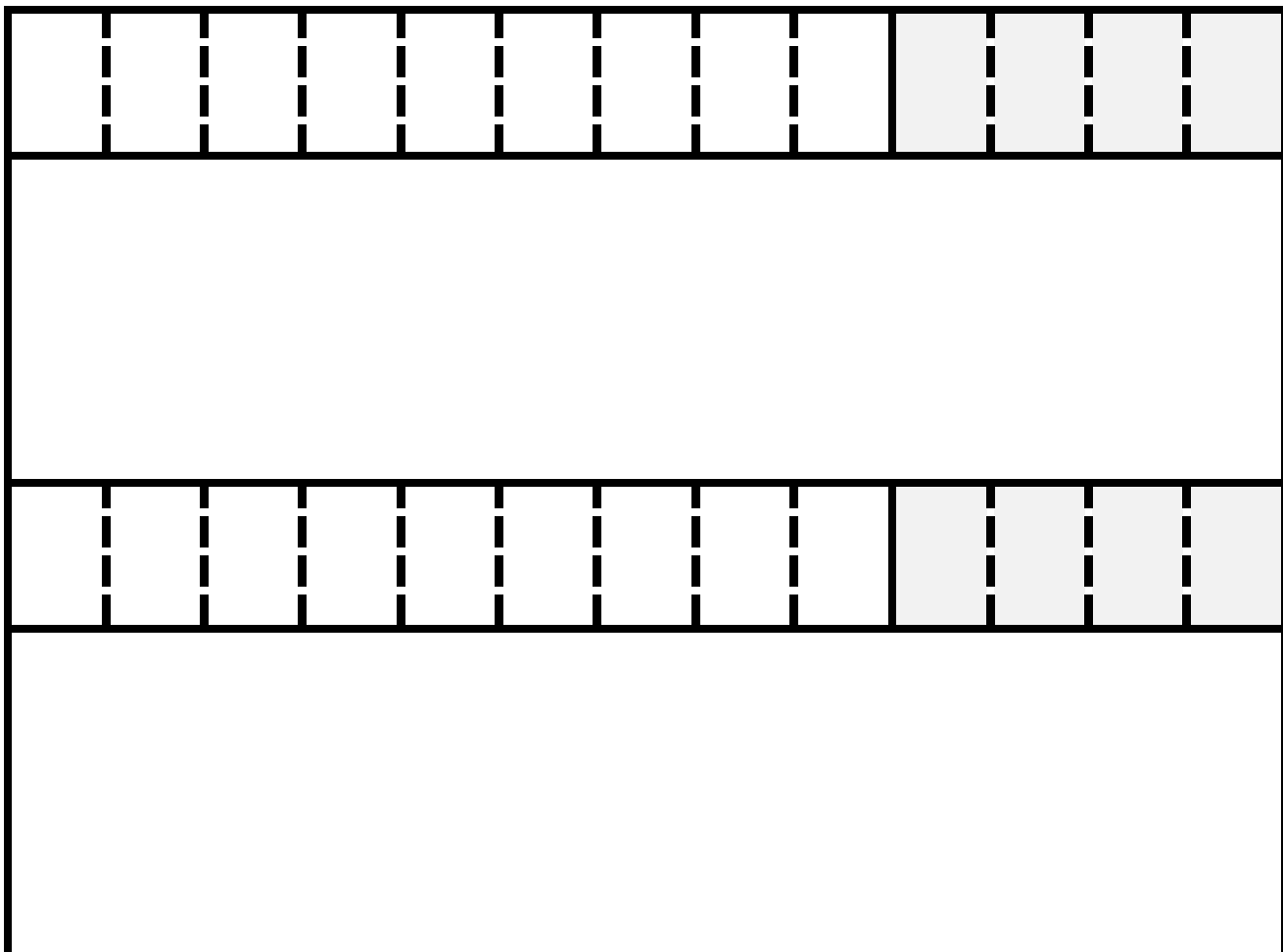
Students will...

- ...use appropriate biotechnology tools to analyze and evaluate DNA fingerprinting data.
- ...evaluate the impact of new DNA fingerprinting data on the working explanation of what's causing the Gulf dead zone.
- ...ask additional questions to clarify and continue refining their model and explanation.

LABEL & SKETCH YOUR GEL

Use the diagram below to label the contents of each well on your gel. Space for 2 rows have been provided – large combs create 9 wells, small combs create 13 wells each.

You should also sketch the results (bands) of your run.



CHESAPEAKE BAY CASE STUDY

Module 3, Activity #8 Debating an Approach to Improved Water Quality

Students will...

- ...engage in argument from evidence provided in a variety of sources.
- ...obtain, evaluate and communicate information in a way that persuades others to appreciate the position presented.
- ...generalize information in a way so that it can be used in other settings.

Your stakeholder group: _____

Research your stakeholder group's position and record your findings here:

Consider the following questions:

- 1) Was the public participation component of TMDL development sufficient?
- 2) Are students personally - regardless of the position they were asked to assume - supportive of or against the EPA's approach to implement the watershed management plans?
- 3) Are there any flaws in the EPA's approach to developing the TMDL?

Discuss this question: Could a TMDL like the one for Chesapeake Bay be considered as a possible solution for the Gulf Dead Zone problems?

A PART OF THE SOLUTION

Module 3, Activity #9

A Document-Based Case Study

Students will...

- ...use evidence presented to engage in argument from evidence.
- ...write a cohesive, substantive response to the provided prompt.
- ...demonstrate knowledge of woodchip bioreactors, the nitrogen cycle and the Gulf Dead Zone and how the 3 are interrelated.

Document A

Document description: _____

Source (if known): _____ Date: _____

What aspects of the problem does it address?

- Water quality
- Social or political issues
- Woodchip bioreactors
- Nitrogen Cycle

How does this document support the use of woodchip bioreactors?

How does this document support NOT using woodchip bioreactors?

Document B

Document description: _____

Source (if known): _____ Date: _____

What aspects of the problem does it address?

- Water quality
- Social or political issues
- Woodchip bioreactors
- Nitrogen Cycle

How does this document support the use of woodchip bioreactors?

How does this document support NOT using woodchip bioreactors?

Document C

Document description: _____

Source (if known): _____ Date: _____

What aspects of the problem does it address?

- Water quality
- Social or political issues
- Woodchip bioreactors
- Nitrogen Cycle

How does this document support the use of woodchip bioreactors?

How does this document support NOT using woodchip bioreactors?

Document D

Document description: _____

Source (if known): _____ Date: _____

What aspects of the problem does it address?

- Water quality
- Social or political issues
- Woodchip bioreactors
- Nitrogen Cycle

How does this document support the use of woodchip bioreactors?

How does this document support NOT using woodchip bioreactors?

Your Decision
