Case Study #1:

The Gulf of Mexico Dead Zone

COLLECT EVIDENCE ● ESTABLISH LINKS ● MAKE AN ARGUMENT

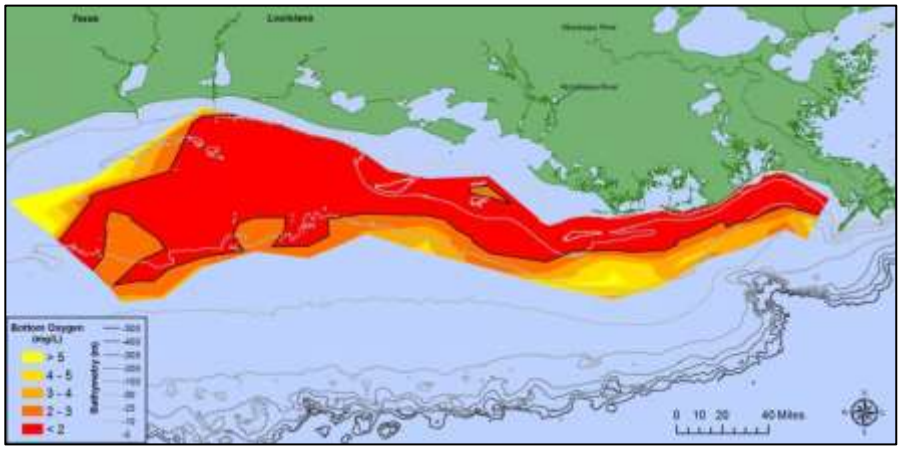
An investigation into the real-world impacts of nitrate pollution and how scientists are trying to solve it.

Name: _____

Biotechnology Outreach

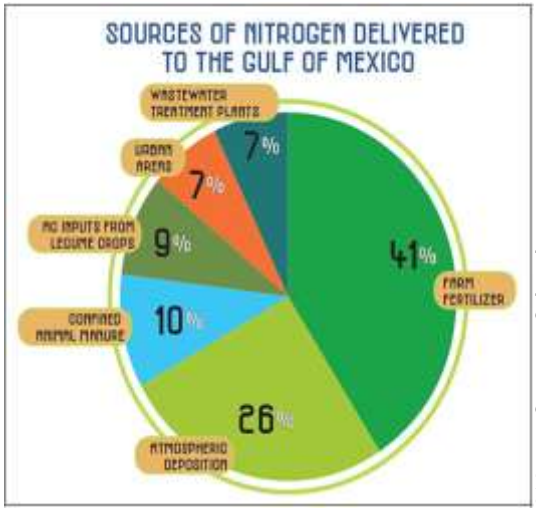
Document A: The Dead Zone

The Gulf of Mexico is a fun place to swim, fish, or boat, but scientists have proven that the Gulf of Mexico might be changing before our eyes. Each year, scientists track the Gulf of Mexico Dead Zone. The Dead Zone is an area of water that contains too little oxygen for fish and other life to survive. In 2017, the largest ever dead zone was recorded, with a size of 8,776 miles—that's about the size of New Jersey!



The 2017 Gulf of Mexico Dead Zone. (National Centers for Coastal Ocean Science)

The Gulf Dead Zone forms each year because of nutrient runoff. When farmers apply fertilizer to their field, rain and the water they use on their crops can carry the fertilizer away. The fertilizer contains nutrients like nitrates, which help plants grow. When the fertilizer is carried into waterways, the nitrates also help aquatic plants grow, such as algae. As the algae grows, it uses oxygen, which takes it away from other creatures that may need it. This process creates low oxygen zones that animals cannot live in.



Water Science School.

Algae Growth in the Gulf of Mexico. (Science Education and Resource Center at Carleton College)

The Gulf of Mexico Dead Zone is bad for animals and humans. People rely on fish that are caught in the Gulf of Mexico for food and business. If we can't find a solution for this problem, the Gulf of Mexico will continue to be harmed.

Document A Questions

What is the Gulf of Mexico Dead Zone?

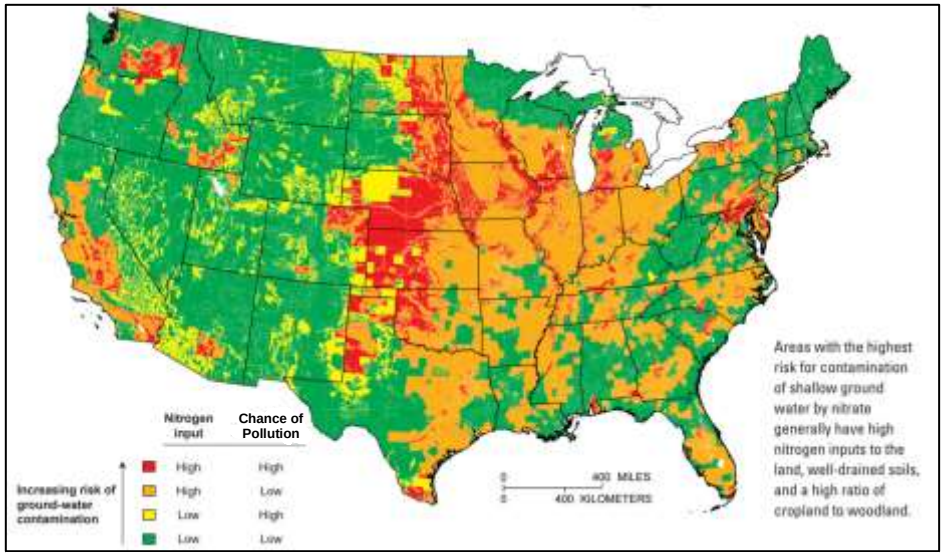
Why does the dead zone form?

How does the dead zone affect humans?

Predict: How do you think Iowa might affect the Gulf Dead Zone?

Document B: The Iowan Issue

The Gulf of Mexico Dead Zone makes it clear that America must change how it farms to protect the environment. Many states, including Iowa, have made plans to reduce nitrate runoff. These plans include many different strategies, like woodchip bioreactors or manmade wetlands. These strategies reduce the amount of nitrates in runoff, which helps prevent the pollution of surface water.



Map showing ground-water nitrate pollution risk. (U.S. Geological Survey)

Iowa especially needs these solutions. As a farming state, Iowa uses a lot of fertilizer. The map above shows that Iowa uses a high amount of nitrogen each year. Farm runoff in Iowa will likely enter the Mississippi River. Scientists have found that Iowa is responsible for a lot of nitrogen pollution. In fact, if you removed Iowa from the data, the Gulf's nitrate amount would have decreased by almost 44,000 tons over the last 5 years. The actual nitrate amount has gone up by 52,000 tons. That's a big difference!

Iowa is taking steps toward reducing its nitrate load. The Department of Natural Resources (DNR) has implemented the Nutrient Reduction Strategy, but the strategy is voluntary and has no deadlines. Because of this, progress has been slow. In 2018, Iowa released 426,416 tons of nitrates, which is 100,000 tons more than 2017. Two of the solutions that the DNR is focused on are woodchip bioreactors and wetlands. There are currently 27 bioreactors in Iowa, which serves about 2,000 acres of farmland. Bioreactors reduced nitrate loss by 12 tons in 2018. Iowa has 86 wetlands that treat 107,000 acres. Overall, these wetlands reduced the nitrate load by 329 tons. We'll learn more about these methods in the following documents.

Document B Questions

Using the map, what region or states have the highest pollution risk? Can you think of any reasons why?

Why is Iowa especially important for preventing the Dead Zone?

Are there more bioreactors or wetlands in Iowa? Which is responsible for more nitrate removal?

Based on the data, do you think Iowa is doing enough to prevent nitrate runoff?

Document C: Woodchip Bioreactors

Woodchip bioreactors are an important part of Iowa's fight against nitrate pollution. In class, we are using a syringe-sized bioreactor, but they are much, much bigger in real life. On a farm, bioreactors are often 100 feet long. That's about as long as 2 school buses! Bioreactors are built underground and take water from the tiling, or drains, from underneath crop fields. The woodchips in the bioreactor are perfect for growing bacteria. Bacteria are tiny creatures that can do a lot of different things, including make you sick. The bacteria in bioreactors are very useful because they can transform nitrate into gas. The gas will float harmlessly into the air instead of polluting the water.

Bioreactor construction. (Ohio State University Extension)

Dr. Michelle Soupir is a scientist that studies woodchip bioreactors. She has worked at Iowa State University since 2008. Her lab has many projects surrounding water quality. One current project looks at replacing woodchips in bioreactors with corn cobs. This solution would be cheaper for farmers and limit waste from their fields. The Soupir lab has 9 pilot scale, or test-sized, bioreactors that they study at Iowa State. Woodchip bioreactors are a tool we can use to limit nitrate pollution, and Dr. Soupir is figuring out how to best use them.

Dr. Michelle Soupir (left) and graduate student Alexis Slade examining a pilot scale bioreactor. (Water Quality Research Lab)

	Cost	Size	Location	Time	Removal
Bioreactor Fast Facts	$8,000	9,000ft^3 or 0.05 acres	Edge of field, underground	10-40 years	43% of nitrates

Document D: Man-Made Wetlands

Wetlands are another way that scientists and farmers prevent nitrate runoff. Wetlands are man-made ponds that sit at the edge of a farmer's field. To make a wetland, farmers locate their runoff area. Then, the wetland is dug out to the correct size. They are designed to catch the water as it flows through the drainpipes away from the farm. As it fills up, bacteria and plants begin to live there. Wetlands are similar to woodchip bioreactors because the bacteria are responsible for removing the nitrates, and then the clean water flows out of the wetland. Besides removing nitrates, wetlands are good habitats for plants and animals.

An Iowan wetland. (The Des Moines Register)

Dr. Matt Helmers is a scientist at Iowa State University that studies wetlands and other nitrate removal methods. His lab focuses on researching how to remove nitrates and reaching out to farmers to help implement new strategies. The lab oversaw the construction of 5 wetlands in 2015. Besides wetlands, his lab is researching how prairie strips and row crops can prevent runoff. These methods use other plants and crops at the field edge to catch and use excess nitrates. As we learn more about nitrate removal, we gain new ways to combat the pollution that creates the Gulf of Mexico Dead Zone.

Dr. Matt Helmer (The Des Moines Register)

Wetland Fast Facts	Cost	Size	Location	Time	Removal
	$13,000	9.8 acres	Drainage area near farm	30-50 years	52% of nitrates

Compare and Contrast

	Woodchip Bioreactor	Wetland
Cost		
Materials		
Location		
Size		
Time		
Impact		

What do woodchip bioreactors and wetlands have in common? How are they different?

_____

_____

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_____

Should Iowa use woodchip bioreactors, wetlands, or a combination to solve our nitrate runoff problem? Why do you think so?

_____

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_____

Construct an Argument!

Consider Farmer Franny and her pond. If she told you she was deciding between a woodchip bioreactor and a wetland, what would you recommend? Consider cost, space, effectiveness, and the other areas of the table. You can use the town map in the back of your student booklet to understand the land Franny is working with. The only wrong answer is one without evidence!

Claim:

I think Franny should use a _____ to reduce the nitrates in her pond.

Evidence:

Reasoning:

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