

# MOVE N AROUND

■■■■■■■■ THE NITROGEN CYCLE GAME

## INSTRUCTIONS

This game will demonstrate the Pivot Bio Nitrogen Cycle. It will highlight how nitrogen can be productive and beneficial, or be lost to the environment and unproductive.

### CLASS SIZE:

30 PEOPLE

### RESOURCES NEEDED:

- Printer
- Scotch tape
- A location that allows students to move from station to station
- Cards (to be printed out by instructor)
- Station signs (to be printed out by instructor)

## PREPARATION

To represent the different places nitrogen may travel during the cycle, we'll have 8 stations for this game. Stations will be placed/taped-up around the room, and students will move to a particular station when they draw the appropriate card. Most stations will have a deck of cards where the students can continue their nitrogen journey, but some are effectively "dead ends" that trap the students in those forms of nitrogen.

The stations and cards will need to be printed, cut, and ready for game set up.

**You'll only need to print 1 copy of each of the station signs.** Below is a breakdown of how many copies of each of the cards you'll need to print. There are four cards per sheet of paper.

### CARD PRINTING INSTRUCTIONS

- **Algal Blooms:** 4 copies (total of 16 cards)
- **Ammonia/Um:** 5 copies (total of 20 cards)
- **Atmospheric Nitrogen:** 12 copies (total of 48 cards)
- **Biological Nitrogen Fixation:** 2 copies (total of 8 cards)
- **Haber-Bosch:** 7 copies (total of 28 cards)
- **Nitrate:** 12 copies (total of 48 cards)
- **Nitrogen Deposition:** 8 copies (total of 32 cards)
- **Nitrogen Oxides:** 4 copies (total of 16 cards)
- **Nitrous Oxide:** 2 copies (total of 8 cards)
- **Other End of Productive Ag:** 7 copies (total of 28 cards)
- **Productive Ag:** 7 copies (total of 28 cards)



# GAME SET UP

## DESK SET UP

 <p>YOU ARE...</p> <p>ATMOSPHERIC NITROGEN (<math>N_2</math>)</p> <p>As atmospheric nitrogen, you're pretty happy. It will take 700°F and 200 times the pressure of the atmosphere to convert you to a form of nitrogen living things can use. Or, a tiny microbe can do it using a specialized enzyme and some sugar. Biology is amazing.</p>	 <p>MOVE N AROUND</p> <p>THE NITROGEN CYCLE GAME</p>	 <p>MOVE N AROUND</p> <p>THE NITROGEN CYCLE GAME</p>
<p><b>A</b></p> <p><b>Atmospheric Nitrogen</b></p>	<p><b>B</b></p> <p><b>Nitrogen Fixing Card</b> Either Haber-Bosch or Biological Nitrogen Fixation</p>	<p><b>C</b></p> <p><b>Cycle Card Deck</b> Based on card assigned from B</p>

**A)** First, place an Atmospheric Nitrogen Card face up on the left-hand side of the desk.

**B)** Then, place either a Haber-Bosch Card or a Biological Nitrogen Fixation (BNF) Card face down on the desks to the right of the Atmospheric Nitrogen Card. There should be approximately five students assigned Haber-Bosch, to every one student assigned to BNF.

**C)** Finally, build decks of three cards to start the student journey through the nitrogen cycle place a deck of three cards face down on the right-hand side of the desk. To maximize movement, shuffle each of the decks before placement so that the top card varies from student to student. We'll go over this deck's breakdown on the following page. The number of specific cards in each deck will be notated in parentheses.

## DESK SET UP: CYCLE CARD DECK BREAKDOWN

**Haber-Bosch** students will receive a 3-card deck consisting of the following:

- Atmospheric Nitrogen\* **(1)**
- Productive Agriculture\*\* **(1)**
- Loss card\*\*\* **(1)**, distributed as follows for 25 students:
  - Nitrate **(15)**
  - Ammonia/Um **(5)**
  - Nitrogen Oxides **(3)**
  - Nitrous Oxide **(2)**

**Biological Nitrogen Fixation** students will receive a 3-card deck consisting of the following:

- Productive Agriculture\* **(2)**
- Loss card\*\* **(1)**, distributed as follows for 5 students:
  - Atmospheric Nitrogen **(1)**
  - Nitrate **(2)**
  - Ammonia/Um **(1)**
  - Nitrogen Oxides **(1)**
  - For additional BNF decks, add Nitrate and Atmospheric Nitrogen Cards before adding Ammonia and/or Nitrogen Oxide Cards.

### Haber-Bosch FAQs:

\* 20% of Haber-Bosch nitrogen returns to the atmosphere through a process called “denitrification.”

\*\* 40-50% of Haber-Bosch nitrogen supports productive agriculture.

\*\*\* Haber-Bosch nitrogen is lost to the environment at the following ratios: 30% as nitrate, 10% as ammonia, 5% as nitrogen oxides, and 1% as nitrous oxide.

### Biological Nitrogen Fixation FAQs:

\* It’s estimated that 80% of nitrogen fixed by BNF supports the plant.

\*\* Of the 20% of BNF nitrogen presumed to be lost, it was lost in the following ratios: 20% lost as atmospheric nitrogen, 30% as nitrate, 10% as ammonia, 5% as nitrogen oxides, and 1% as nitrous oxide.

## STATION SET UP

Print out the station signs and place them around the room. Encourage visualization of the cycle by linking steps in the cycle together. For example:

- Place the Nitrogen Deposition Station between the Ammonia and Nitrogen Oxides Stations to show that both of those forms of nitrogen contribute to nitrogen deposition.
- Place the Productive Agriculture and The Other End of Productive Agriculture Stations next to one another.
- Separate the Nitrous Oxide and Algal Blooms Stations as these are both dead ends to the cycle.

Next, set up each station with the deck of cards listed below. There will be multiples of specific cards in each deck, as notated in parentheses below. **Please note that you'll need to shuffle each deck of cards!**

## STATION BREAKDOWN

### 1. Productive Agriculture Station

#### Cards:

- Other End of Productive Ag (20)
- Nitrous Oxide (5)
- Ammonia/Um (5)

### 2. Other End of Productive Ag Station

#### Cards:

- Productive Ag (5)
- Atmospheric Nitrogen (10)
- Nitrate (15)
- Nitrous Oxide (2)
- Nitrogen Oxides (4)
- Ammonia/Um (4)

### 3. Ammonia/Um Station

#### Cards:

- Nitrogen Deposition (20)
- Nitrous Oxide (1)
- Productive Agriculture (9)

### 4. Nitrogen Deposition Station

#### Cards:

- Nitrate (15)
- Productive Agriculture (10)
- Algal Blooms (5)

### 5. Nitrate Station

#### Cards:

- Algal Blooms (10)
- Atmospheric Nitrogen (10)
- Nitrous Oxide (1)
- Ammonia/Um (5)
- Nitrogen Oxides (4)

### 6. Nitrogen Oxides Station

#### Cards:

- Nitrogen Deposition (10)
- Ammonia/Um (4)
- Nitrous Oxide (1)

### 7. Algal Blooms

No cards. Game over/dead end.

### 8. Nitrous Oxide

No cards. Game over/dead end.



**How did we come up with the number of cards per station? Great question!**

The cards in the deck roughly reflect the amount of nitrogen that converts from one form to another at that station.

For example: Nitrates in waterways contribute to algal blooms, but they can also be converted into atmospheric nitrogen or nitrous oxide.



**Don't forget to shuffle the card decks for each station!**

## HOW TO PLAY

Have the students sit at their desk and introduce the nitrogen cycle:

“

Take a deep breath.

How much of that breath was nitrogen?

**Answer:** 80% of the breath you just took was nitrogen, but your body can't do anything with it. Atmospheric nitrogen has to be fixed to be useful to living things.

”

Inform the class that their desk is the atmosphere. Pick a volunteer to read the bottom of the Atmospheric Nitrogen Card that was placed on their desk.

Next, have the students flip over the Nitrogen Fixation Card on their desk. Pick a volunteer to read the Haber-Bosch text, and a volunteer to read the BNF text.

“

Raise your hand if you're part of the Haber-Bosch process. Now, how about biological nitrogen fixation?

Today, we can only replace part of synthetic nitrogen fertilizer made by Haber-Bosch with biological nitrogen fixation, but scientists are working hard to make this tool the cornerstone of agricultural fertilizer management programs.

Both of these processes fix atmospheric nitrogen into ammonia, which living things can use to build DNA and proteins. This is the start of your journey into the nitrogen cycle. Let's see where you go from here!

”

Instruct the students to take the top card from the Cycle Card Deck, hold on to it, and move to the station it indicates. Let the students know that they should keep all of the Cycle Cards they collect as they travel around the room. Allow for a few minutes while people sort out where it is they should be. After the first card draw, students should be scattered across the room with the majority at the Productive Agriculture, Nitrate, and Atmospheric Nitrogen Stations.

Guide the classroom discussion by picking one of the stations, having a student read out loud the statements at the bottom of the card, and discussing that station with the whole class. Continue until every station has been highlighted and students have collected five or six cards showing their nitrogen journey. Students that draw Atmospheric Nitrogen Cards should return to their desk and pick another journey card from the deck provided to them. Students that land at Algal Blooms and Nitrous Oxide Stations reach the end of their journey early.

## **AWARDING PRIZES**

You can award prizes for the cards that have been collected based on the following:

- **“Most Productive”** for the student with the highest number of Productive Agriculture Cards
- **“Longest Journey”** for the student with the most Nitrogen Cycle Cards
- **“Most Creative”** for the student that collected cards for the most stations

## TALKING POINTS

The following suggested talking points can guide discussion through four rounds of the game. Feel free to mix and match as your students move around the room—you may have a student at the Nitrous Oxide or Algal Bloom Station right at the beginning, for example. Or, you may want to have nitrate (a form of nitrogen that connects to nearly every other facet of the nitrogen cycle) pick cards in round one or two so that you can spread students out at the beginning of the game.

### Suggested Talking Points for Round 1:

- **Some of you are still in the atmosphere**—why do you think that is? It turns out that soil bacteria convert about 20% of fixed nitrogen back into atmospheric nitrogen. It is kind of frustrating to use all that energy making fertilizer just to have microbes convert it right back into its original form! Every time you get an Atmospheric Nitrogen Card you should return to your desk. For now, pick another card, hold on to it, and move to your next station.
- **Nitrate** Select a volunteer to read the note at the bottom of the Nitrate Card.  
What the heck you guys? You had one job to do and you're already goofing off?! It's not really your fault—you just get carried away by water... literally. It's estimated that 30% of all the synthetic nitrogen fertilizer we apply washes out of the field and into rivers and streams, but this number can get up to 60% if it's a really wet year. Hold tight for now—I'll let you know when it rains again.
- **Productive Agriculture** Select a volunteer to read the note at the bottom of the Productive Agriculture Card.  
Congratulations, you're part of the 40% of nitrogen that makes it to a crop and does something useful! You've helped ensure a productive harvest, but what happens after harvest? Pick a card from the deck, add it to your journey, and then move to that station.

## Suggested Talking Points for Round 2:

- **Other End of Productive Agriculture** Select a volunteer to read the note at the bottom of The Other End of Productive Agriculture Card.

Welcome back to the nitrogen cycle folks! About a third of the corn we grow will become ethanol to fuel our cars, but most of the corn we grow goes to feed animals (and sometimes humans). And well, they're sending that nitrogen right back out into the world. Pick a card to find out the next step in your nitrogen journey!

- **Nitrogen Oxides** Select a volunteer to read the note at the bottom of the Nitrogen Oxides Card.

Nitrogen oxides are only about 5% of the nitrogen loss that farmers experience. While they don't contribute directly to greenhouse gas emissions, they combine with ammonia to cause respiratory issues and make air quality a lot worse.

- **Ammonia** Select a volunteer to read the note at the bottom of the Ammonia Card.

Nitrogen just doesn't stay put! Just like nitrogen oxides, ammonia interacts in the atmosphere with other pollutants, like sulfur oxides from car exhaust, to impact air quality and create smog. Neither of these nitrogen forms last for long while they're in the air, but they can do some real damage while they are there. Those at the Nitrogen Oxides and Ammonia Stations, pick a card from the deck and move to your next station.

## Suggested Talking Points for Round 3:

- **Nitrogen Deposition** Select a volunteer to read the note at the bottom of the Nitrogen Deposition Card.

Nitrogen can travel pretty far from the field pretty quickly; and when it lands in a new place, it can disrupt whole ecosystems by feeding plants that wouldn't otherwise have an advantage. Sometimes this means it returns to agricultural land and feeds crops. More often, it can unbalance fragile networks like alpine or desert ecosystems. Pick a card and see where you landed.



- **Atmospheric Nitrogen** There are likely several students who have drawn Atmospheric Nitrogen Cards and are sitting at their desk now.

You've been inert long enough! Pick a card and head to your next station.

- **Nitrate** There are likely to be a lot of students at this station now.

Okay folks, it's raining hard. Grab a card and head to your next station!

## Suggested Talking Points for Round 4:

- **Algal Blooms** Select a volunteer to read the note at the bottom of the Algal Blooms Card.

Has anyone ever seen an algal bloom in person? Some algae can be harmful when they're living and all the blooms look pretty gross. It is when they die, however, that it's really bad news. All that nitrogen supercharged their growth; and when they run out of nitrogen, they die all at once. Their decomposition uses up all the oxygen in the water. This process causes over 500 "dead zones" across the world where aquatic creatures can't survive. The biggest dead zone is in the Gulf of Mexico. Any guesses how large it is? It averages 7,000 sq. km, or about the size of New Jersey. You guys are just going to sink to the bottom of your body of water and stay there for the rest of the game.

- **Nitrous Oxide** Select a volunteer to read the note at the bottom of the Nitrous Oxide Card.

Congratulations, you're effectively immortal! Nitrous Oxide is a little bit like a vampire—it hangs around forever. Not only is it a greenhouse gas 300 times more potent than carbon dioxide, it also chews up the stratospheric ozone layer, which weakens our protection from UV rays. You're going to be in the atmosphere for a long, long time—get comfy.

- **All stations** Repeat until time is up and/or cards run out at a station.

Algal blooms and Nitrous Oxide aren't going anywhere, but the rest of you are still very much in the nitrogen cycle! On my mark, everyone grab a card and continue your journey!



PRODUCTIVE AGRICULTURE

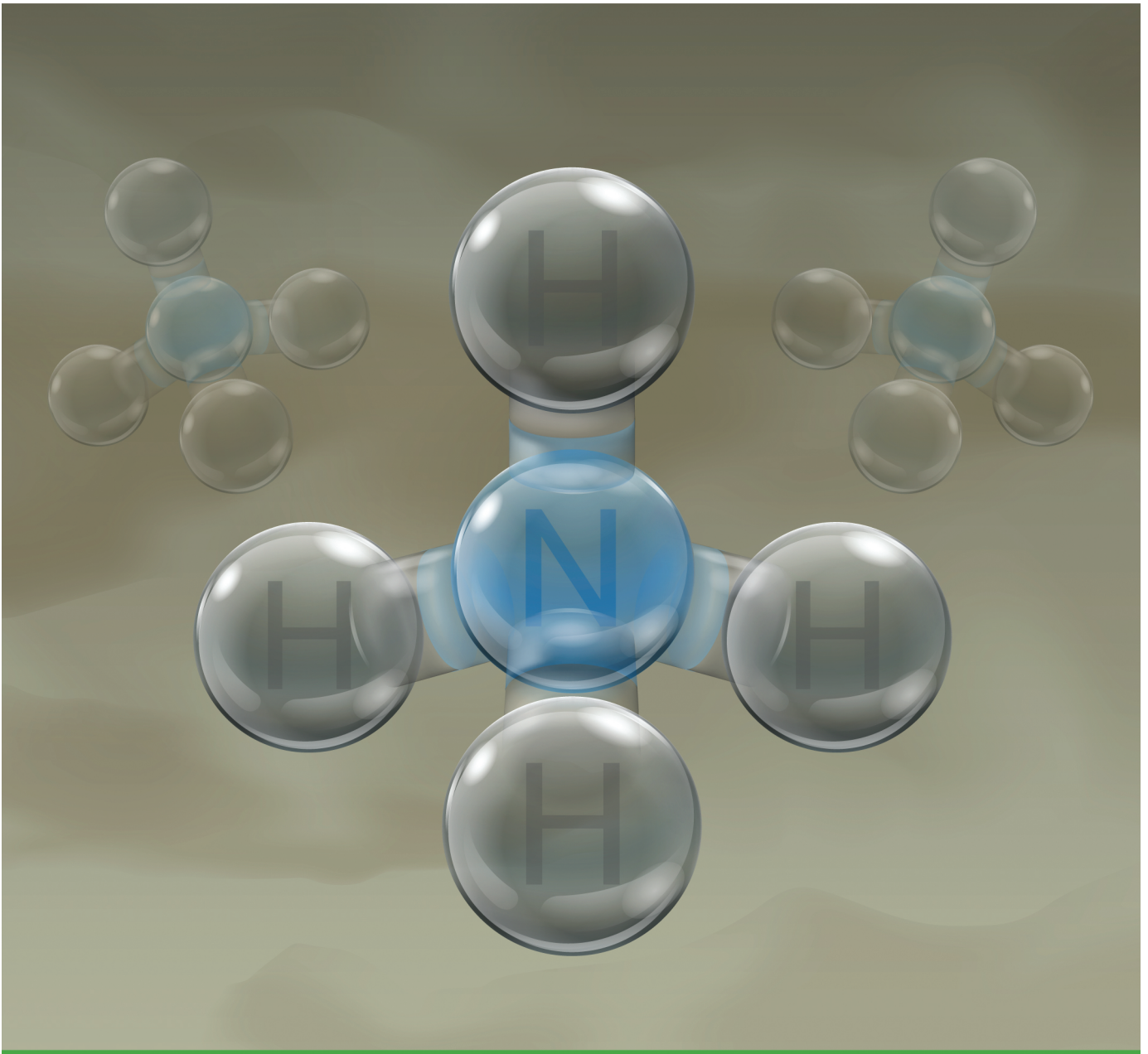
STATION





THE OTHER END OF  
PRODUCTIVE AGRICULTURE

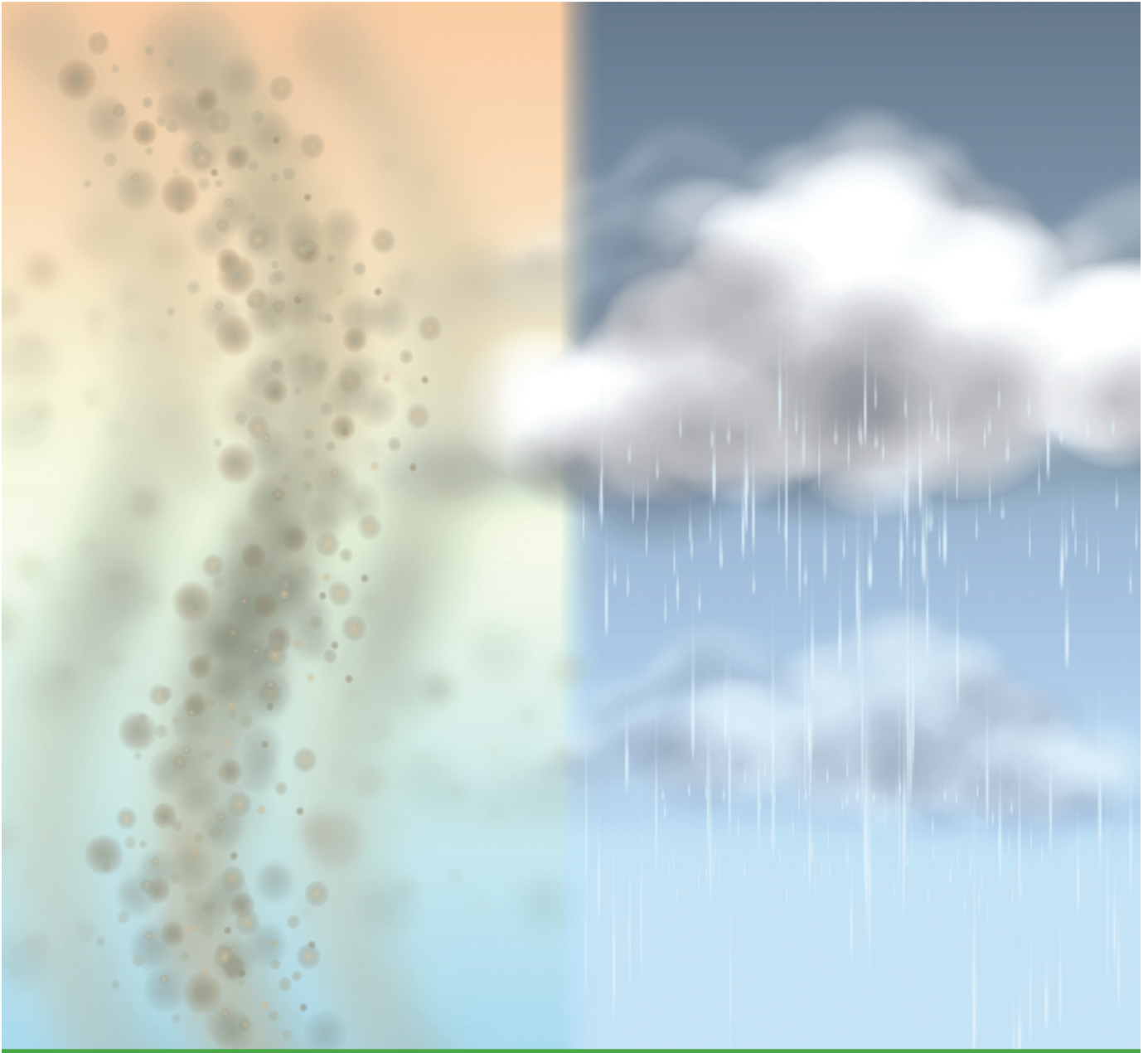
STATION



AMMONIA/UM ( $\text{NH}_4^+$ )

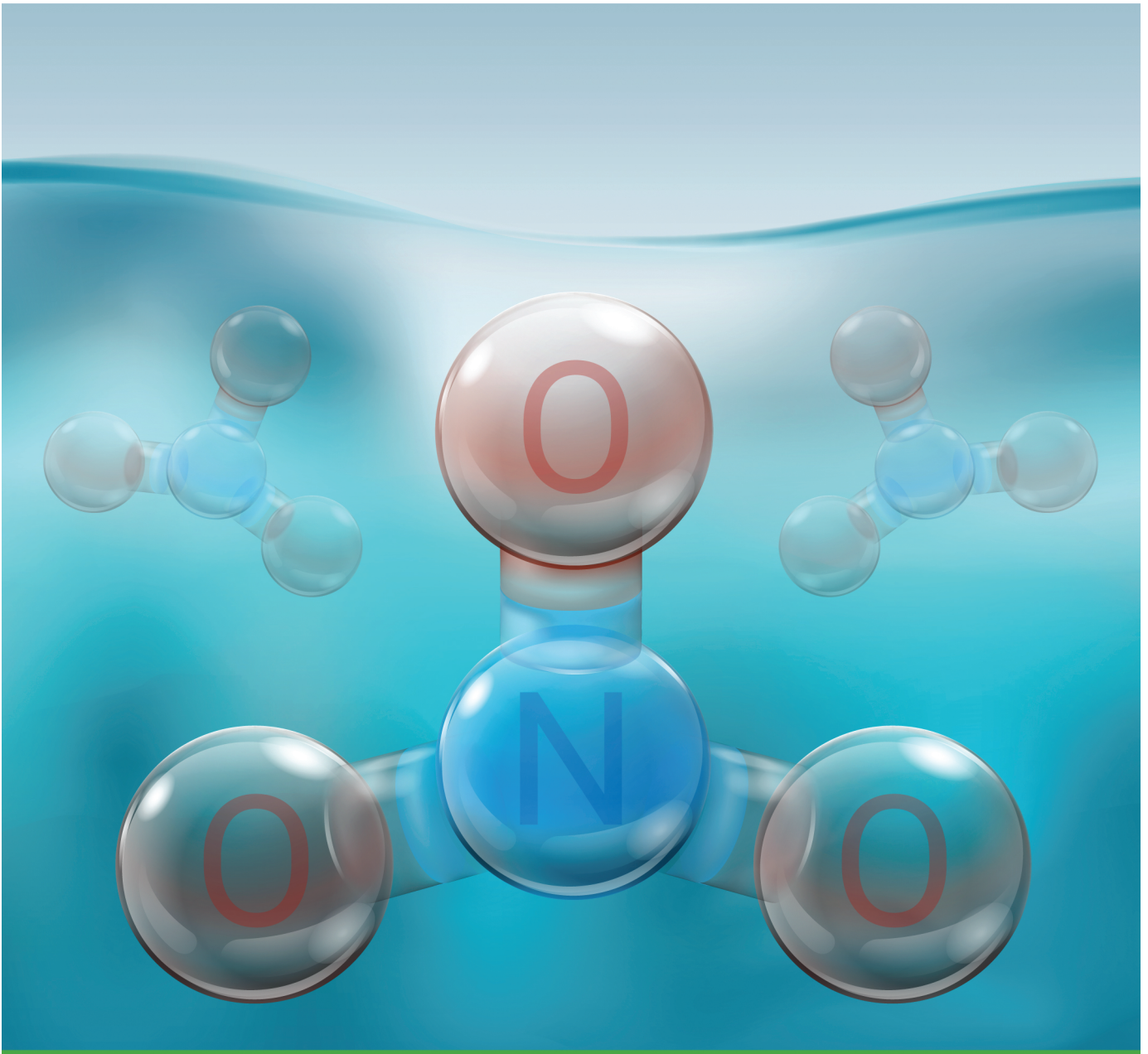
STATION





NITROGEN DEPOSITION

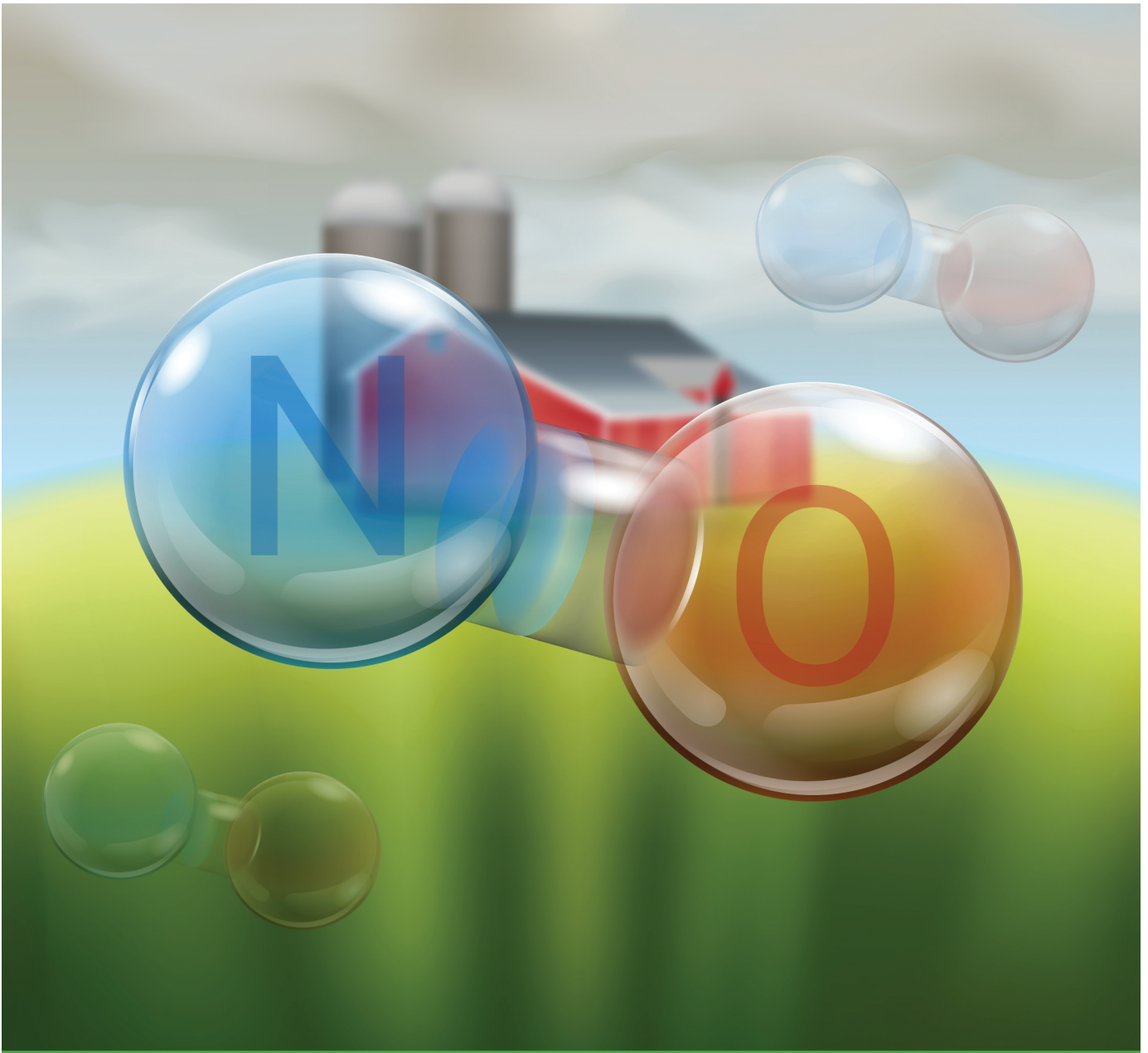
STATION



NITRATE (NO<sub>3</sub>)

STATION

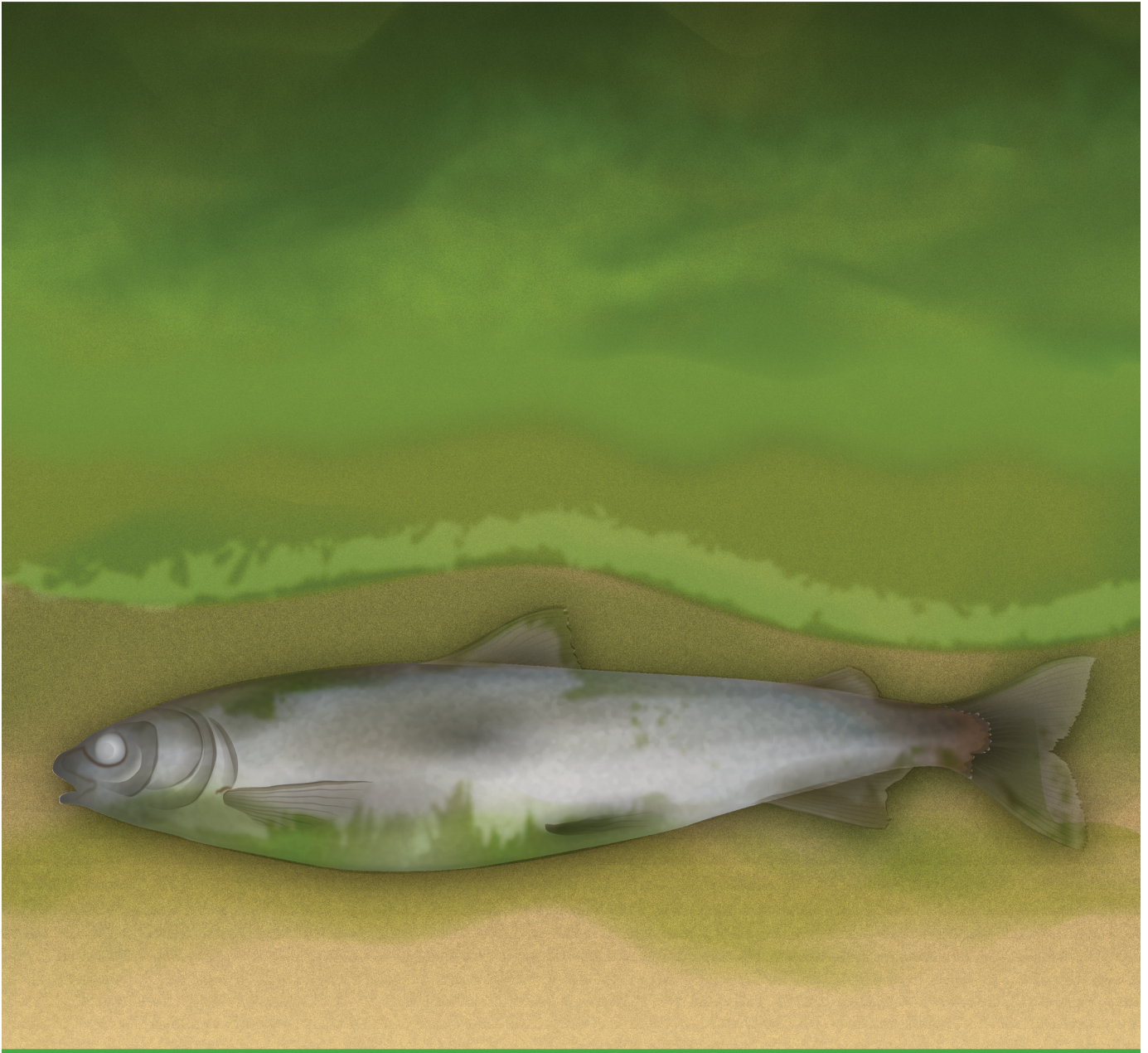




NITROGEN OXIDES ( $\text{NO}_x$ )

STATION

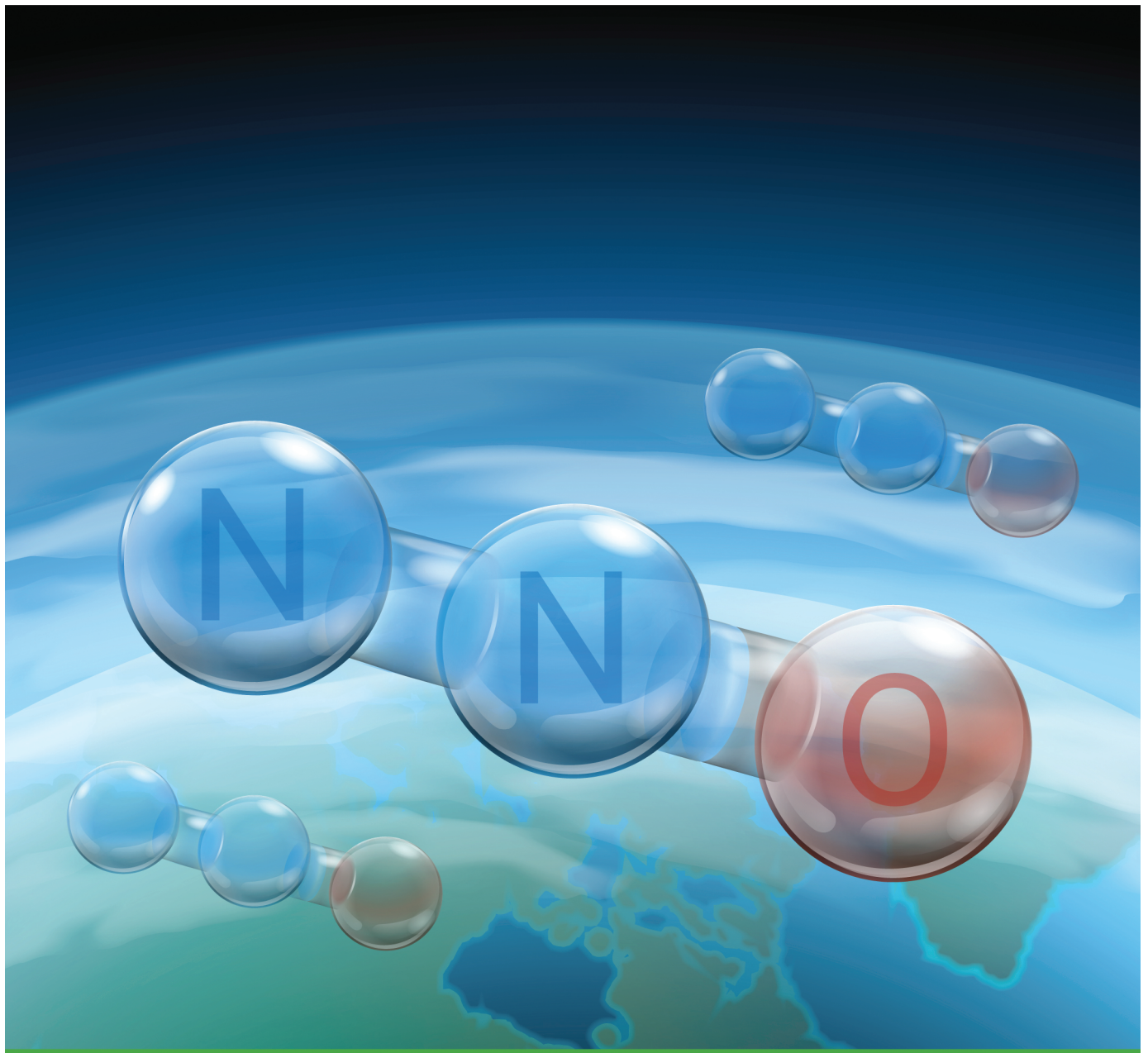




ALGAL BLOOMS

STATION





NITROUS OXIDE ( $\text{N}_2\text{O}$ )

STATION



# MOVE **N** AROUND

■■■■■■■■ THE NITROGEN CYCLE GAME



# MOVE **N** AROUND

■■■■■■■■ THE NITROGEN CYCLE GAME



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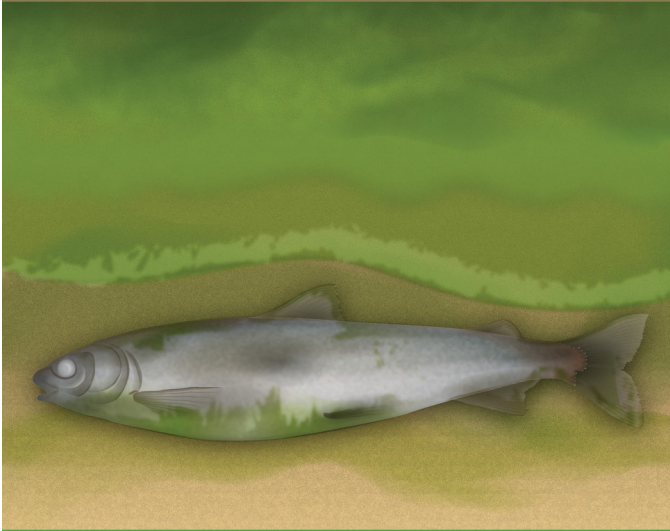
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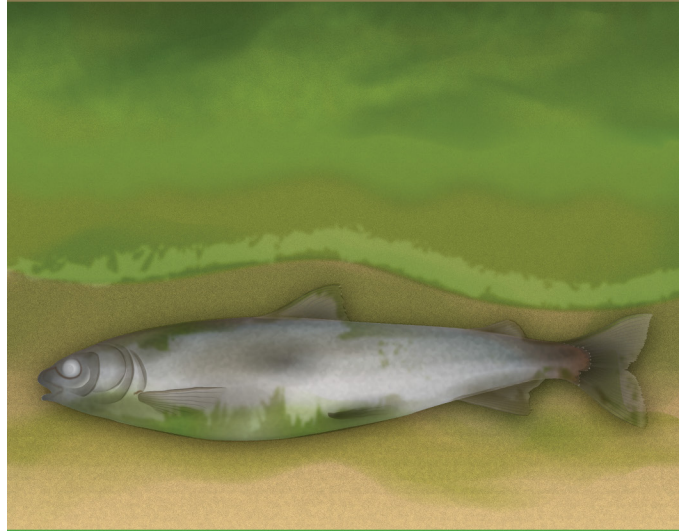
YOU ARE...



ALGAL BLOOMS

Congratulations nitrogen—you ran off and ended up feeding some algae and now they are trying to take over the entire world. The lake is goopy, the Gulf is green, and our vacation is ruined.

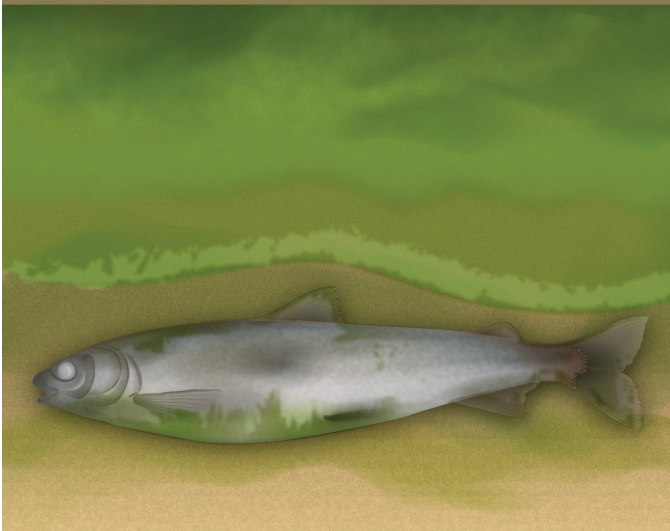
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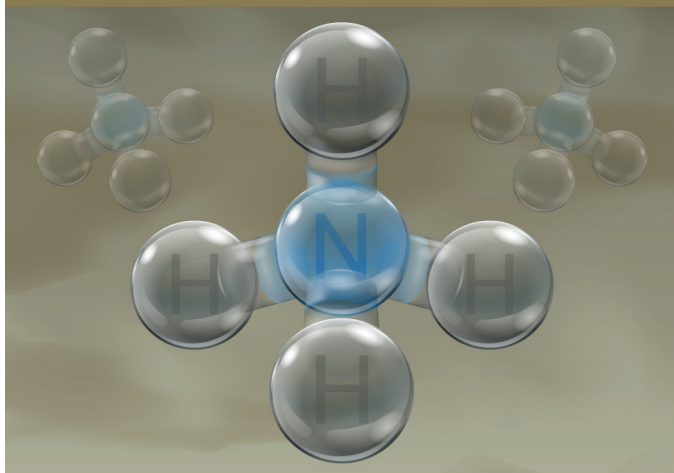


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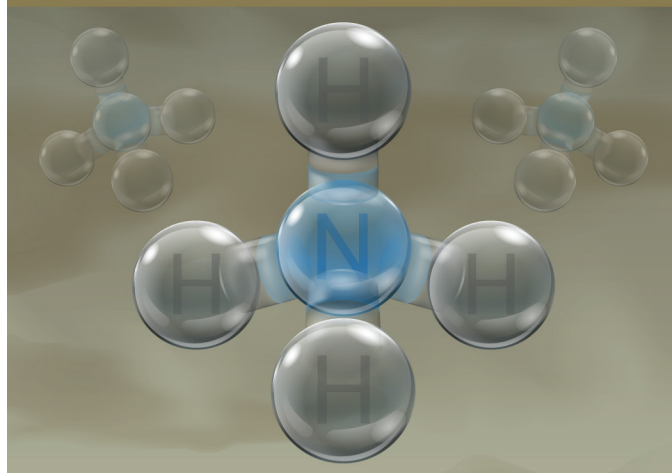
YOU ARE...



AMMONIA/UM ( $\text{NH}_4^+$ )

For a molecule made of only nitrogen and hydrogen, you sure do require a lot of carbon! Every ton of ammonia made by the Haber-Bosch process generates at least three tons of greenhouse gas emissions. Half the time, you don't even stick around—volatilizing into the air and creating smog! Not cool.

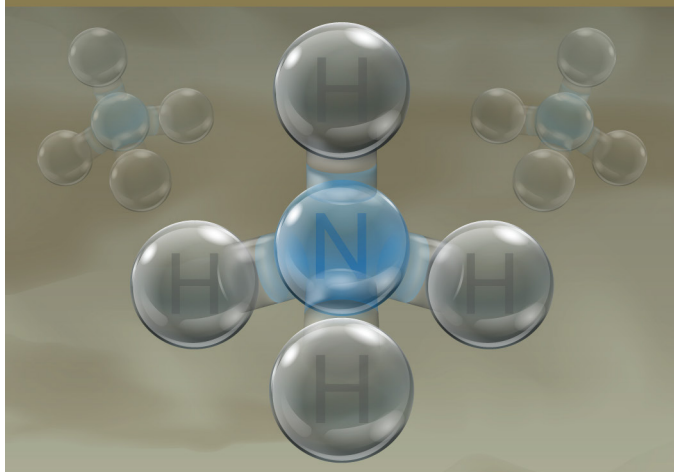
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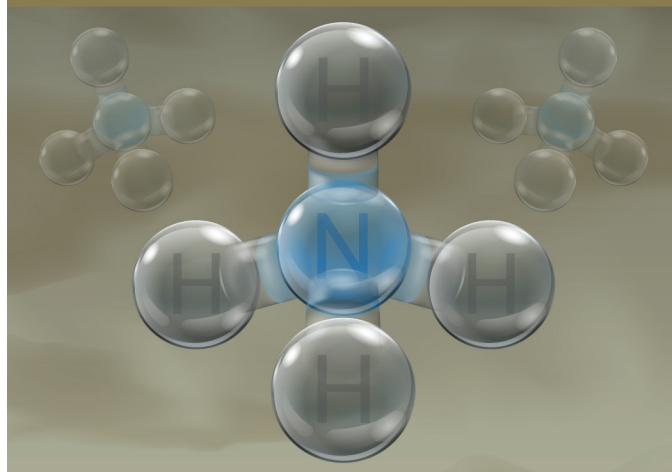
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ATMOSPHERIC NITROGEN (N<sub>2</sub>)

As atmospheric nitrogen, you're pretty happy. It will take 700°F and 200 times the pressure of the atmosphere to convert you to a form of nitrogen living things can use. Or, a tiny microbe can do it using a specialized enzyme and some sugar. Biology is amazing.

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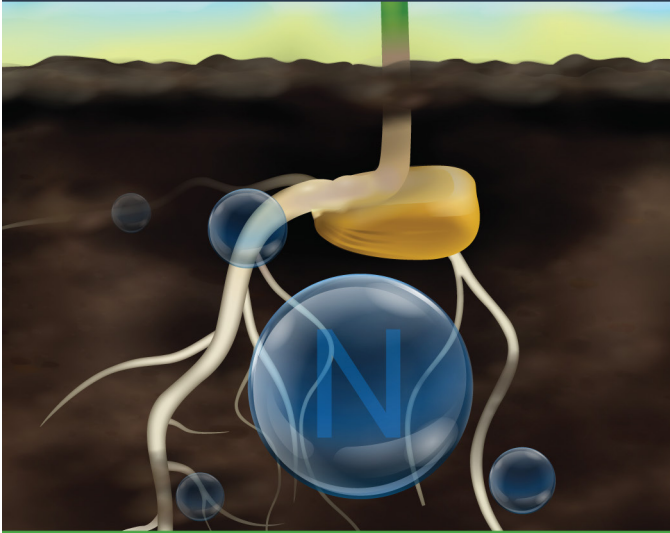


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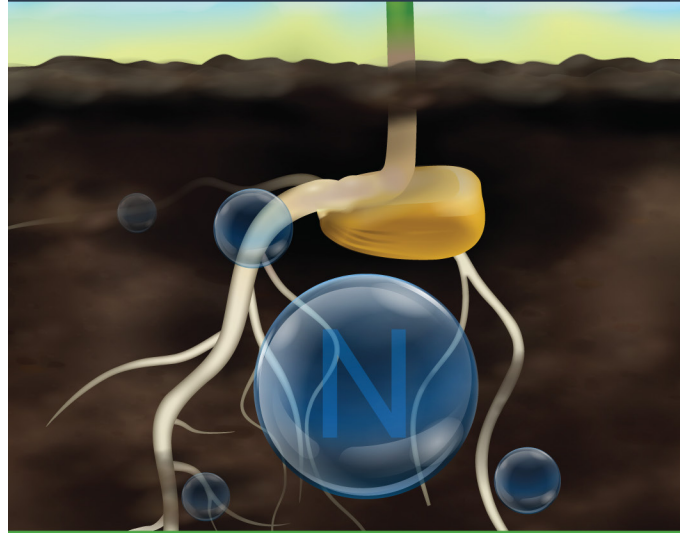
ACTIVATE!



### BIOLOGICAL NITROGEN FIXATION

Nice—you are likely being produced right on some plant roots, in concert with their needs and the environment! No petroleum based industrial process, no long distribution chains—just nitrogen produced right where it's needed. You're doing good work!

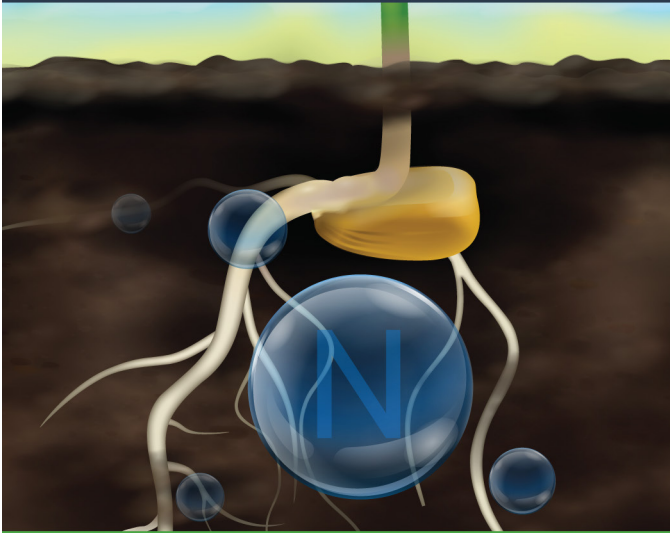
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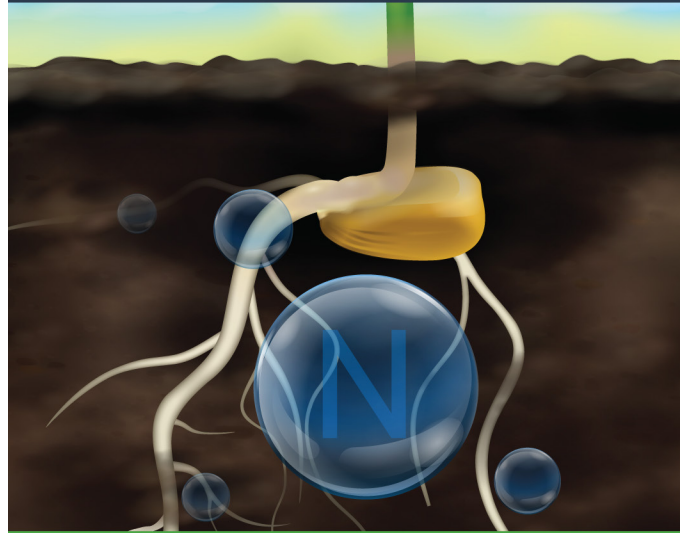
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### The Haber-Bosch Process

The Haber-Bosch process was invented 100 years ago. Every year, it uses 3-5% of the world's liquid natural gas to make 140 million metric tons of fertilizer. This process alone is responsible for 1% of global greenhouse gas emissions. There has to be a better way.

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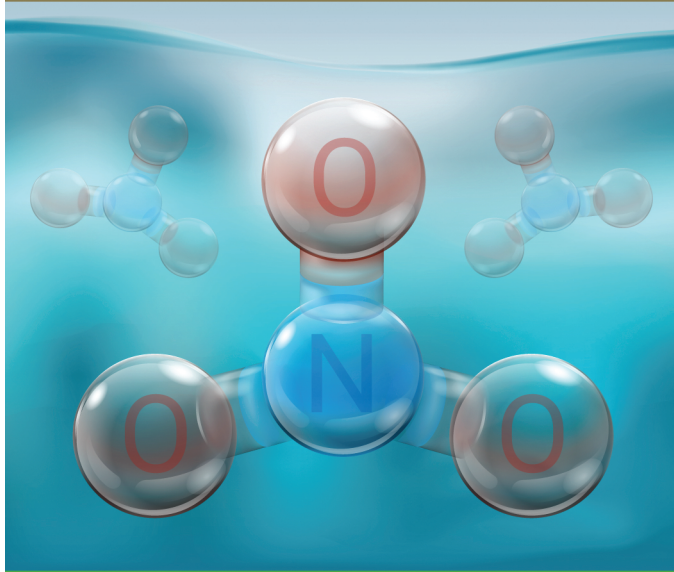


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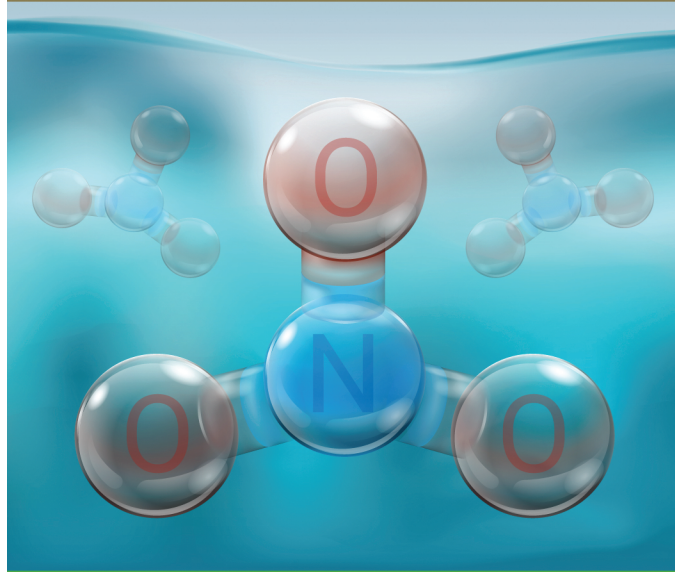
YOU ARE...



NITRATE ( $\text{NO}_3$ )

It'd be cool if you'd stick around to fertilize crops, but we all know you're going to run off into streams, rivers, and groundwater as soon as you have the chance.

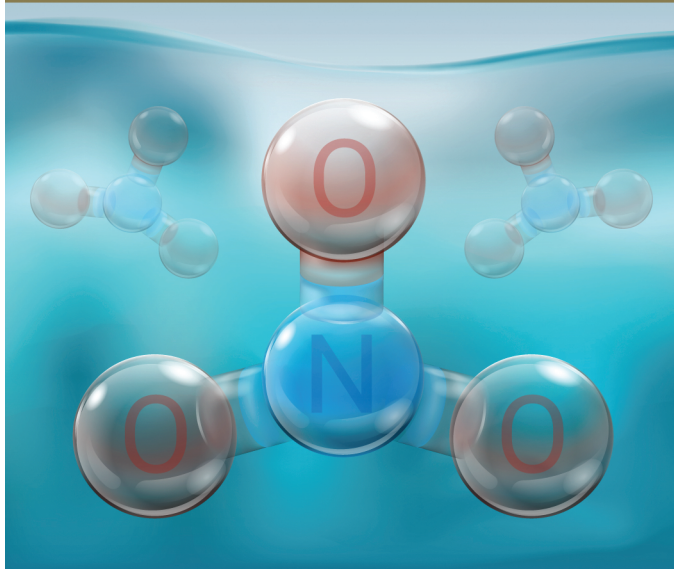
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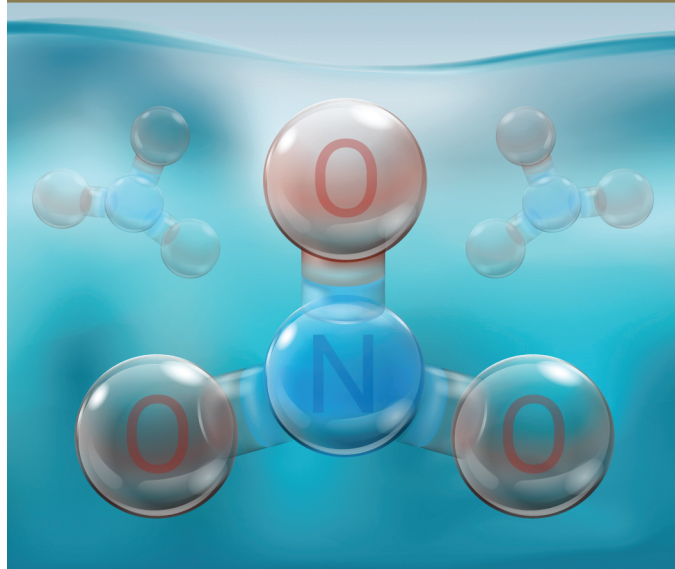
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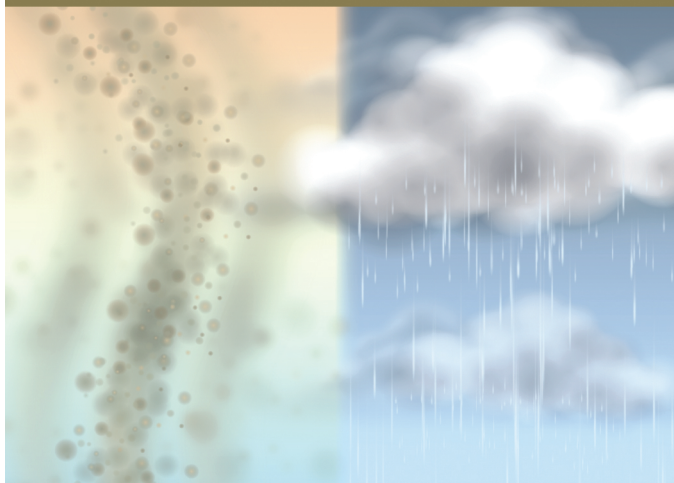


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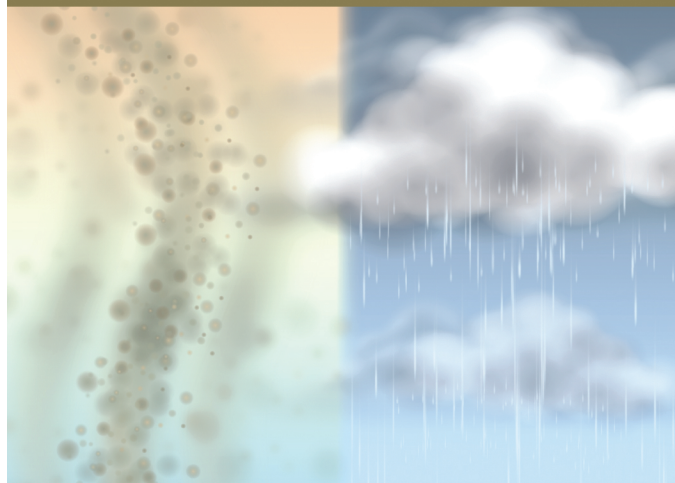
YOU ARE...



NITROGEN DEPOSITION

Who can say where you'll end up after you head out into the atmosphere, except that it is almost certainly not where you're wanted. Pristine mountain lake? Let's turn it green. Fragile ecosystem? Let's reduce biodiversity by feeding plants that couldn't survive otherwise. You're a terrible tourist.

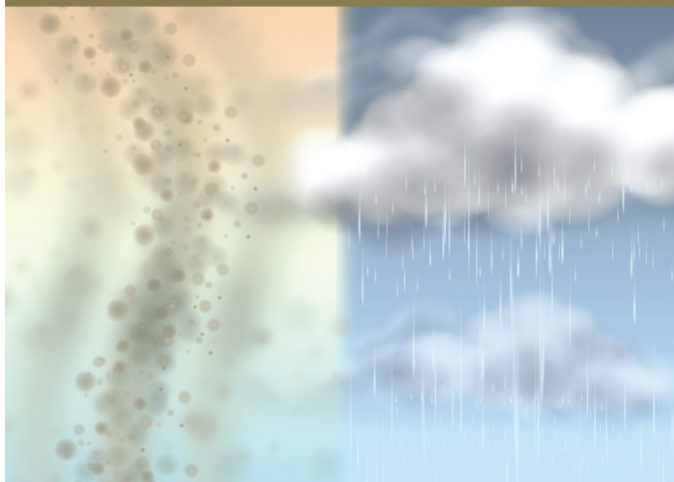
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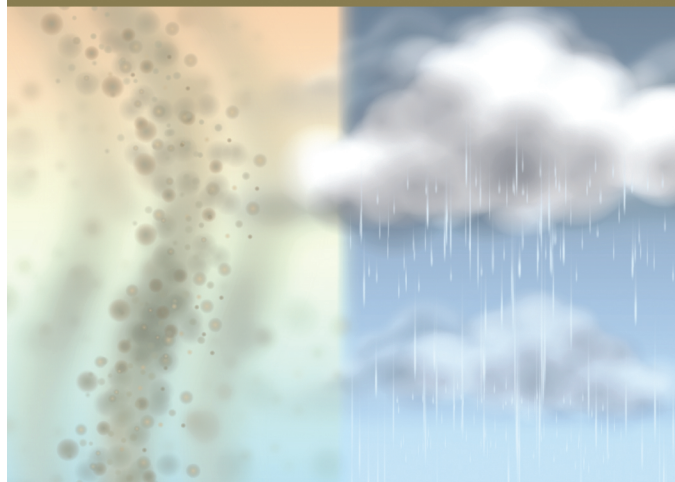
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NITROGEN DEPOSITION

Who can say where you'll end up after you head out into the atmosphere, except that it is almost certainly not where you're wanted. Pristine mountain lake? Let's turn it green. Fragile ecosystem? Let's reduce biodiversity by feeding plants that couldn't survive otherwise. You're a terrible tourist.

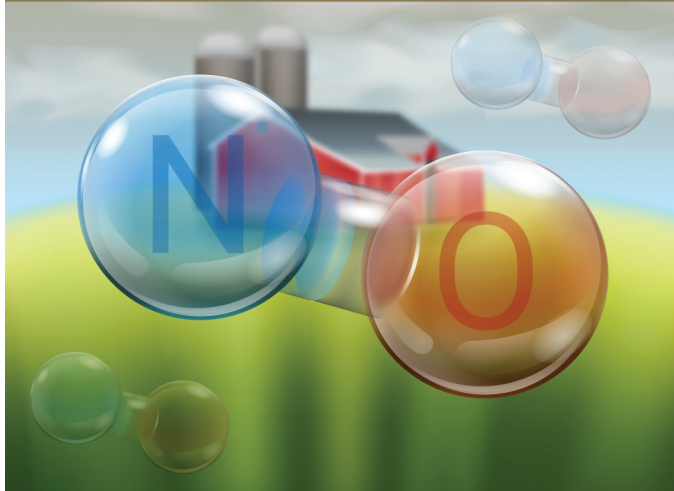
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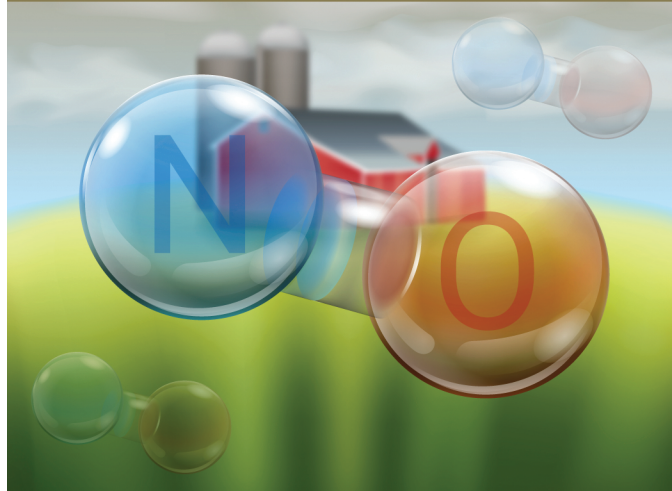
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NITROGEN OXIDES (NO<sub>x</sub>)

Most of your buddies come from forest fires or automobile combustion, but the application of synthetic nitrogen fertilizer is the fastest growing source of nitrogen oxides. As another difficult to measure, hard to define, rapidly changing nitrogen species —let me just say you are exhausting.

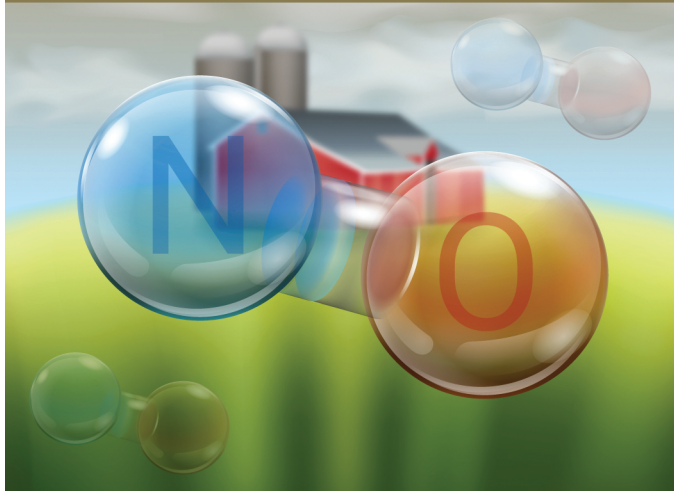
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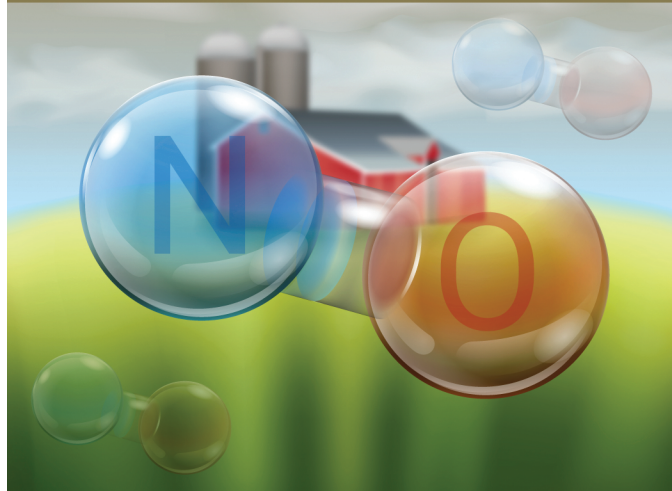
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NITROUS OXIDE ( $\text{N}_2\text{O}$ )

Once you exist, you exist forever. With 300 times the global warming potential of carbon dioxide ( $\text{CO}_2$ ) and no way to recapture you, you are just chewing away at the stratospheric ozone layer.

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### THE OTHER END OF PRODUCTIVE AGRICULTURE

About 10% of the corn we grow becomes industrial products and 30% becomes fuel for our cars. 60% of it goes to feed cows, pigs, chickens and sometimes people! We all know what happens to food once it gets eaten —you'll be back in the nitrogen cycle before you know it.

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