Nitrogen Cycle Game – Post Industrial

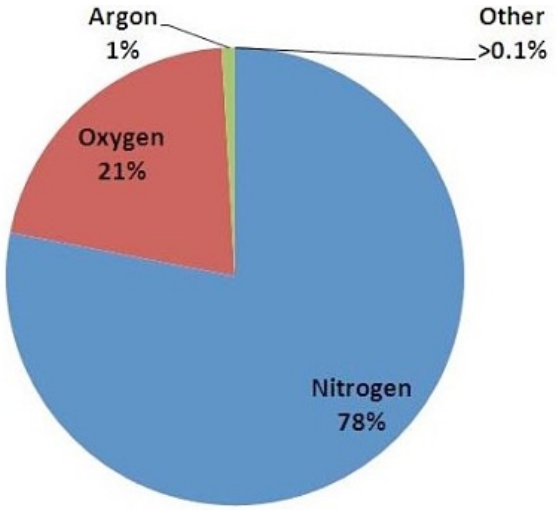
How did you arrive?

Denitrification: Pseudomanas Bacteria from waterlogged soil have transformed you into nitrogen gas and you are now part of the **atmosphere**!

Nitrogen exists in the atmosphere as N2 gas. In **nitrogen fixation**, bacteria convert N2 into ammonia, a form of nitrogen usable by plants. When animals eat the plants, they acquire usable nitrogen compounds

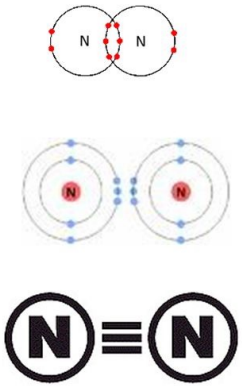
Forest Fire! The wood you were within is burnt and you have been released into the **atmosphere**.

Where are you at?



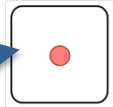
Atmosphere (air)

Nitrogen's triple bond

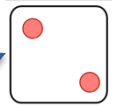


- Although the majority of the air we breathe is N_2, most of the nitrogen in the atmosphere is **unavailable** for use by organisms.
- This is because the strong **triple bond** between the N atoms in N_2 molecules makes it relatively inert (like a noble gas).

Where are you going?

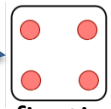


Lightning strikes! It oxidizes atmospheric N2 to make **nitrate (NO3-) in soil**.



the Haber-Bosch process captures nitrogen from the air to make **synthetic fertilizer** for crops.

Nitrogren fixation: Azotobactor Bacteria in soil change (N2) to ammonium (NH4+). travel to **Soil Ammonium!**



Nitrogren fixation: Rhizobium Bacteria in roots of lentil plants extract you from the air (N2) to ammonium (NH4+). Go to **Soil Ammonium**

or

combustion of fossil fuels oxidizes atmospheric N_2 to make nitrate (NO_3-). Go to **Soil Nitrate**

How did you arrive?

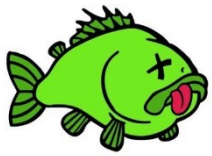
From Rain.

From **runoff** of a fertilizer application

From manure or sewage

From a decomposed plant or animal

When fertilizers containing nitrogen and phosphorus are carried in runoff to lakes and rivers, they can result in blooms of algae—this is called **eutrophication**.



Where are you at?

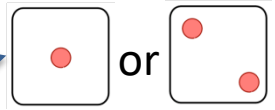
Surface Water

Debrief Question(s):

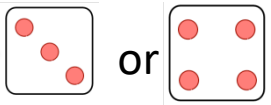
2. If plants need nitrogen to grow, then how will adding extra nitrogen to the water affect the growth of aquatic (water) plants like algae?

a. Aquatic plants will die
b. Aquatic plants will grow rapidly
c. Aquatic plants will not be able to preform photosynthesis.

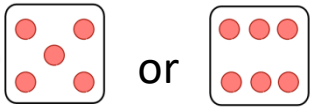
Where are you going?



You are just the sort of nitrogen that plants need to live. You are now within a **live plant**!



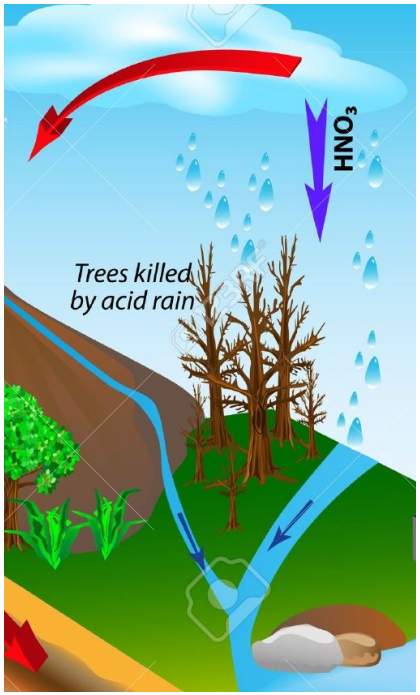
You travel through the rivers and streams to the **ocean**!



You percolate deep underground in the **groundwater**!

How did you arrive?

Since our atmosphere is 78% nitrogen, when it rains some of this element is carried down to the ground in the form of ammonium or nitrates

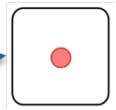


Where are you at?

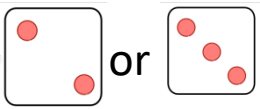
Rain Water

Acid Rain: As more and more nitrogen enters the atmosphere from fertilizer and heat from factories and engines, it is producing nitric acid, HNO3 and N2O.
When it rains, the acids land on trees, lakes, the ocean…

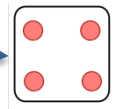
Where are you going?



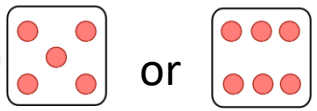
You fall into a lake or stream so now you are part of **surface water.**



You fall on the land and become part of the **soil**!
Go to **Soil Ammonium**



You percolate deep underground in the **groundwater**!



You rain into the **ocean**!

How did you arrive?

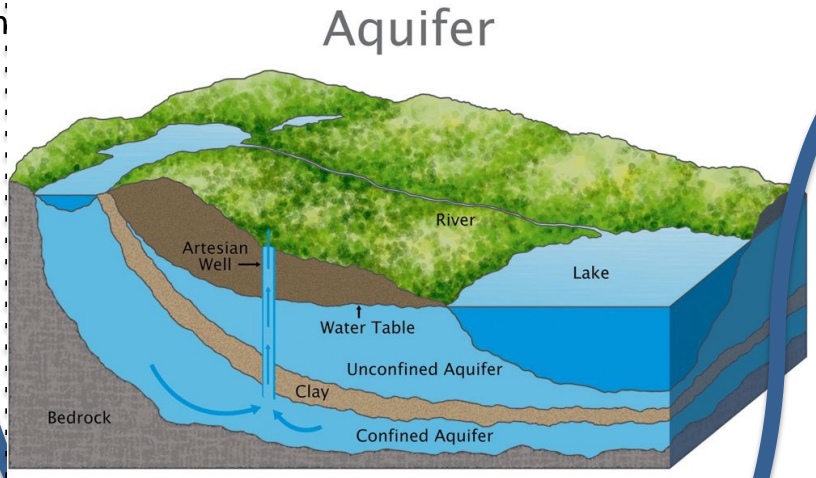
From Rain

From surface water

From the soil

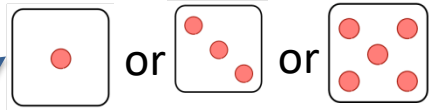
Aquifers are actually water trapped in tiny spaces in rocks underground. As the water travels through the soil to get to the aquifer it is naturally filtered and is very clean.

Where are you at?



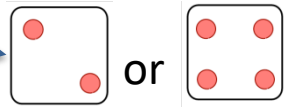
Ground Water

Where are you going?

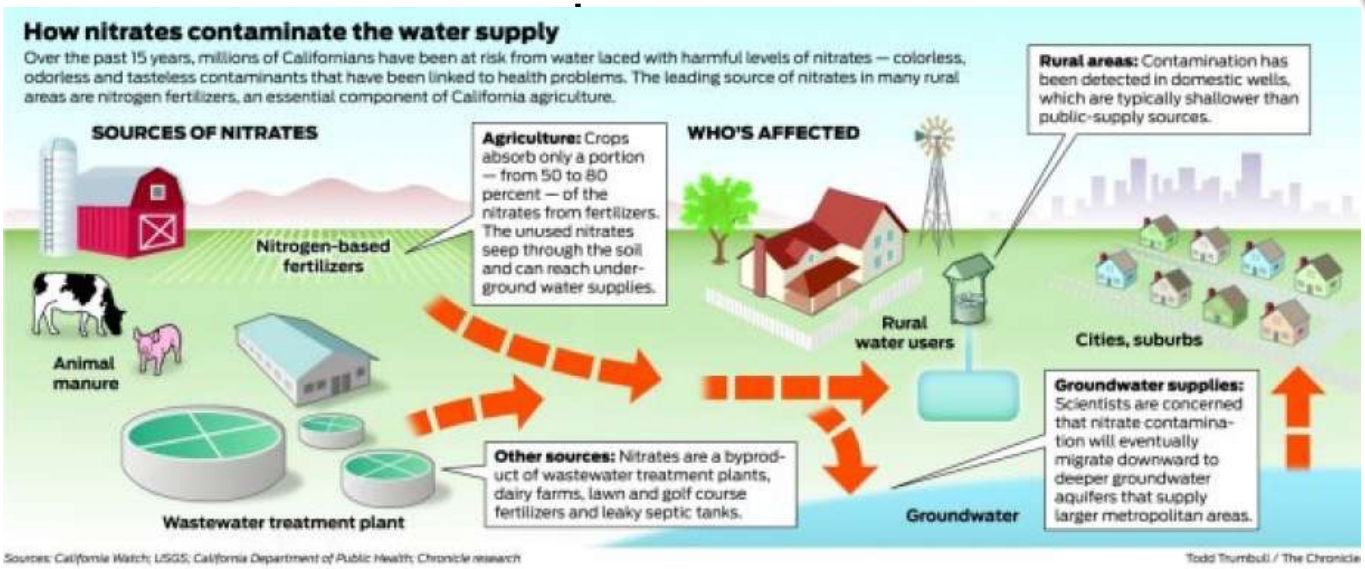


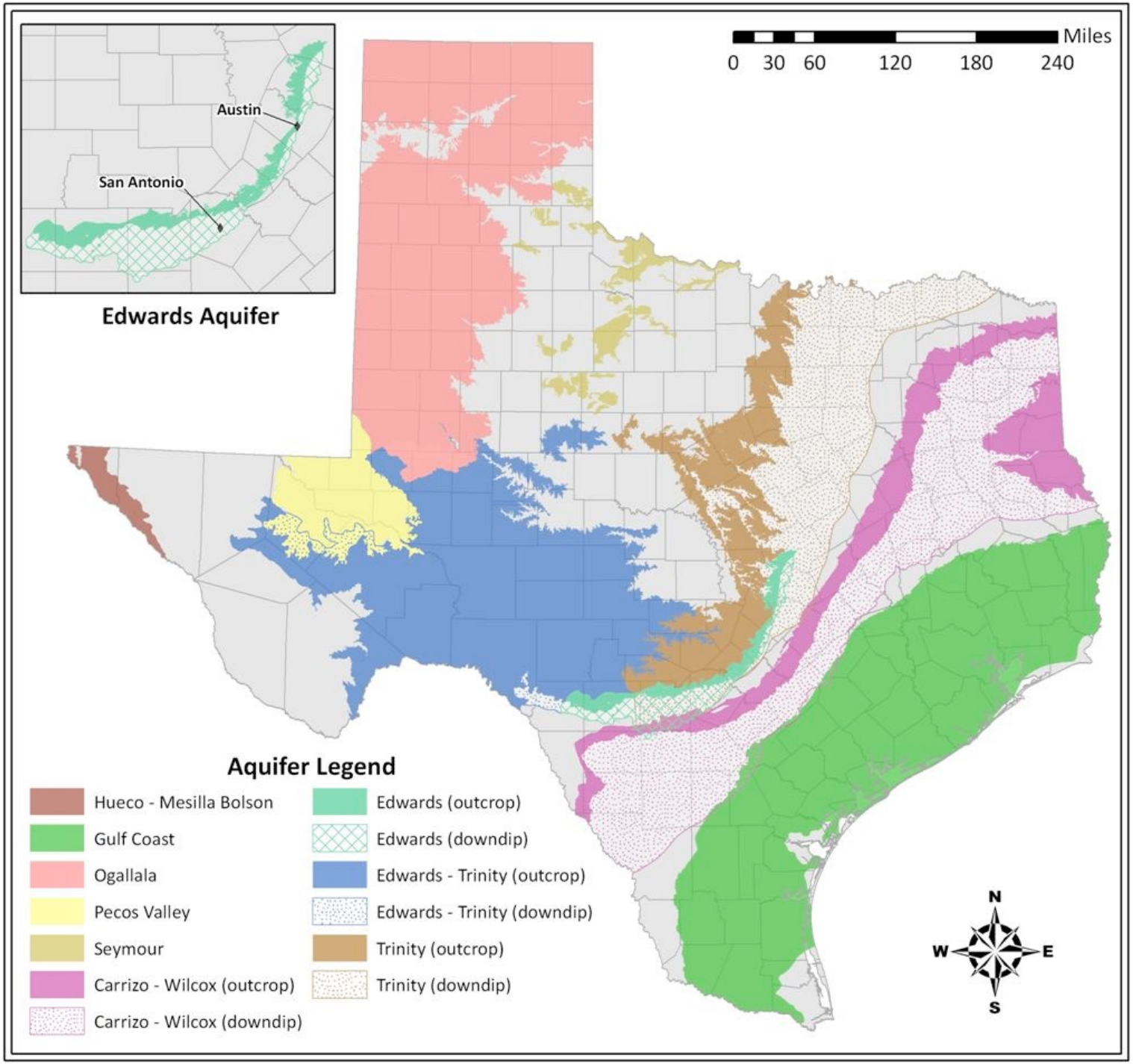
Groundwater moves very slowly. It can take 100s of years for a molecule to leave. Stay here!

The groundwater you are dissolved within travels and you become part of the **surface water**!



The groundwater you are dissolved within travels and you become part of the **ocean**!




Miles
0 30 60 120 180 240
Austin
San Antonio
Edwards Aquifer
Aquifer Legend
Hueco - Mesilla Bolson
Gulf Coast
Ogallala
Pecos Valley
Seymour
Carrizo - Wilcox (outcrop)
Carrizo - Wilcox (downdip)
Edwards (outcrop)
Edwards (downdip)
Edwards - Trinity (outcrop)
Edwards - Trinity (downdip)
Trinity (outcrop)
Trinity (downdip)
N
W
E
S

How did you arrive?

A farm supply company has picked you up and made you into **fertilizer**!

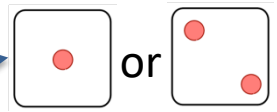
Where are you at?

Organic Fertilizers

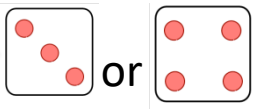
Organics fertilizers

- contain important secondary and trace nutrients;
- improve soil texture, aeration, and drainage;
- provide slow-release nutrition

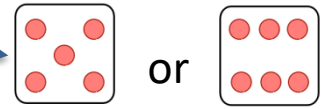
Where are you going?



You dissolve and wash into the **surface water**!



You become part of the **soil ammonium**!



You are just the sort of nitrogen that plants need to live. You are now within a **live plant**!

How did you arrive?

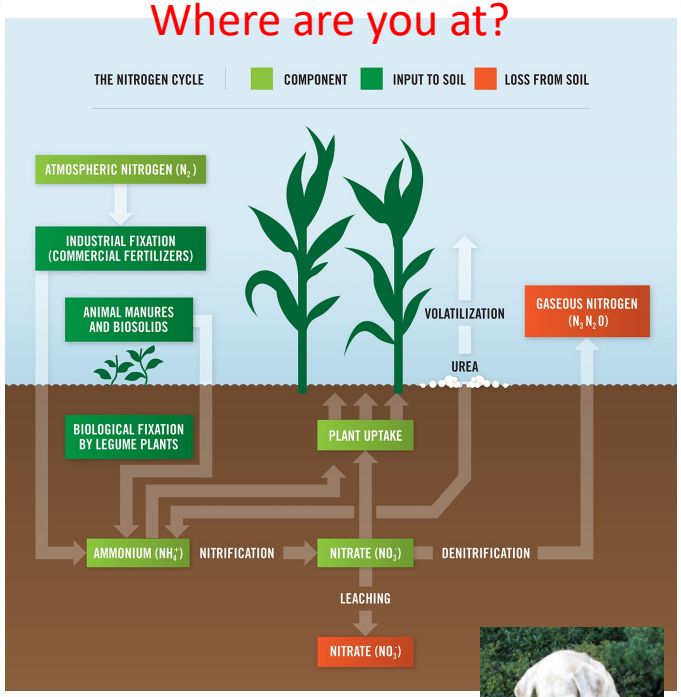
Nitrogen fixation: When a plant or animal dies, decomposers like bacteria or fungi break the DNA, proteins, and chlorophyll into Ammonium (NH_4+) . Too much Ammonium can "burn" plants.

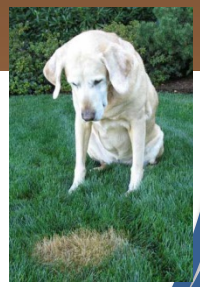
Nitrogen fixation: In water: Blue green algae convert you from atmospheric N2 to Ammonium

Nitrogen fixation: Azerbacter in the soil change (N_2) to ammonium (NH_4+)

Artificial or organic fertilizer

Where are you at?



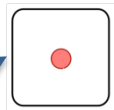


Soil: Ammonium (NH_4+)

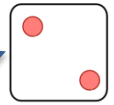
Process: Nitrification

Ammonium (NH_4+) or Nitrites (NO_2-) (that plants cannot use) is converted to Nitrates (NO_3-) (that plants can use) by **bacteria**

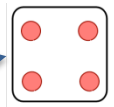
Where are you going?



You dissolve and wash into the **groundwater**!



You dissolve and wash into the **surface water**!




When there are not enough nitrates available, plants can use Ammonium, but it requires extra energy. You are taken into a **plant**!


Nitrification: Nitrosomonas bacteria have transformed you into nitrites (NO2-). You are a deadly poison to both plants and animals! Go to **Soil Nitrites**

How did you arrive?

Nitrification:
Nitrosamanas bacteria break down Ammonium into Nitrite

Nitrites are actually poisonous to both plants and animals!

Blue Baby Syndrome: If a baby drinks formula made with nitrate-rich water, the body converts the nitrates into nitrites. These nitrites bind to the hemoglobin in the body, forming methemoglobin, which is unable to carry oxygen. The poor baby turns blue from lack of oxygen!

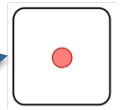
Where are you at?

Soil: Nitrite (NO_2-)

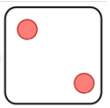
Nitrification

Ammonium (NH_4+) or Nitrites (NO_2-) (that plants cannot use) is converted to Nitrates (NO_3-) (that plants can use) by **bacteria**

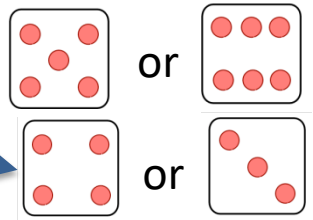
Where are you going?



You dissolve and wash into the **groundwater**!



You dissolve and wash into the **surface water**!



Nitrobacter bacteria convert you to Nitrates that plants can use. Go to **Soil Nitrates**

How did you arrive?

Nitrification: Nitrobacter bacteria convert nitrite (NO_2-) into nitrate (NO_3-) in the soil.

Lightning oxidizes atmospheric N2 to make nitrate (NO3-) that plants can take up during assimilation

Many fertilizers contain nitrates directly

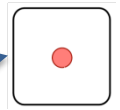
Where are you at?

Soil: Nitrate (NO_3-)

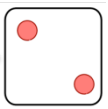
Nitrification

Ammonium (NH_4+) or Nitrites (NO_2-) (that plants cannot use) is converted to Nitrates (NO_3-) (that plants can use) by **bacteria**

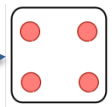
Where are you going?



You dissolve and wash into the **groundwater**!



You dissolve and wash into the **surface water**!


or


You are just the sort of nitrogen that plants need to live. You are now within a **live plant**!


or


Denitrification: The soil is boggy or waterlogged, and Psuedomonas Bacteria have transformed you into nitrogen gas and you are now part of the **atmosphere**!

How did you arrive?

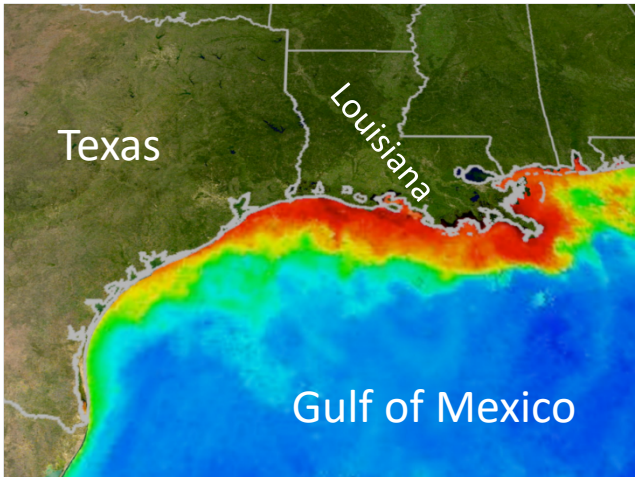
You travel through the rivers and streams to the **ocean**!

You rain into the **ocean**!

You are decomposed and become dissolved in the **ocean**!

The groundwater you are dissolved within travels and you become part of the **ocean**!

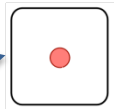
Where are you at?



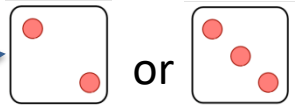
Ocean

In the ocean, nitrogen is a ***limiting factor***. A limiting factor is essential for growth, but frequently is present in only low quantiles. (In fresh water, Phosphorus is the limiting factor) When fertilizers containing nitrogen are applied too heavily, rain can wash them into the ocean, resulting in large blooms of algae—this is called **eutrophication**. A lot of nitrogen compounds enter the Gulf of Mexico (shown in red on the map above) and settle near the coast. This results in large dead zones.

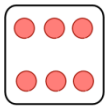
Where are you going?



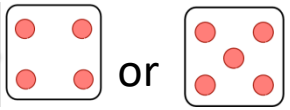
Look out! Water is on the move! You have washed into the **groundwater**!



You are just the sort of nitrogen that plants need to live. You are now within a **ocean plant**!



You fall to the ocean floor, where you are compressed into **sedimentary rock!**



Bacteria have transformed you into nitrogen gas and you are now part of the **atmosphere**!

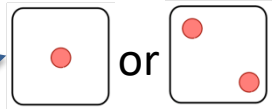
How did you arrive?

Congratulations! The animal that you were within has excreted and you are in its waste. Go to **animal waste**!

Where are you at?

Animal Waste

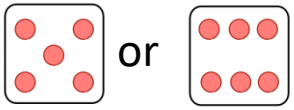
Where are you going?



Look out before someone steps in you! Now you are decomposing in the soil. Go to **soil ammonium**!

A farm supply company has picked you up and made you into **fertilizer**!

In the ocean, poop from whales, seabirds, and spawning fish fertilize plants! Go to **live plants**!

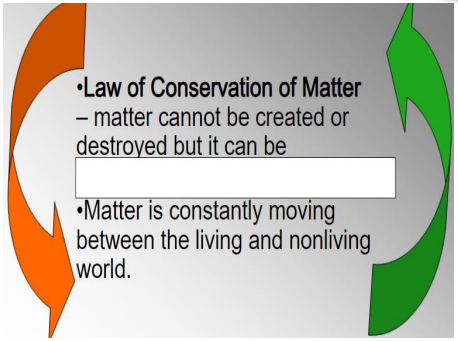


What's that in the water? You have dissolved into **surface water!**

How did you arrive?

The plant that you were within has died..

The animal that you were within has died.

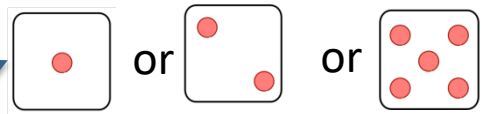


When plants and animals die on land, decomposers such as fungi and bacteria break them down. Their matter is recycled!

Where are you at?

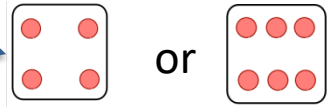
Dead Plants & Animals

Where are you going?



You are decomposed by fungi and bacteria. They break down your chlorophyll, Dna, enzymes, and protein to Ammonium. and become part of the soil. Go to **soil Ammonium**!

You are decomposed and become dissolved in **surface water!**



You are decomposed and become dissolved in the **ocean**!

How did you arrive?

Artificial Fertilizer

Organic Fertilizer

From Soil Ammonium. This requires extra energy from the plant and can burn if too much!

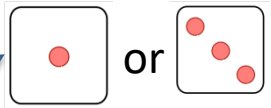
From Soil Nitrates. This is the perfect type of nitrogen that plants can use!

Where are you at?

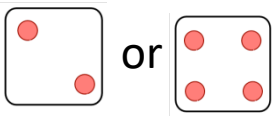
Live Plants

Nitrogen is a common **limiting nutrient** in nature, and agriculture. A limiting nutrient is the nutrient that's in shortest supply and limits growth

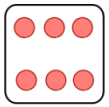
Where are you going?



The plant that you are within has died. Go to **dead plants and animals.**



An animal has eaten the plant that you are within! Go to **live animals**!



Cyanobacteria, algae, lichens, mosses, and liverworts form living crusts on many desert soils. These organisms can **fix** nitrogen from the atmosphere into ammonium in the soil. Go **to Nitrogen Sink: Sedimentary rock and desert soil**

You have died, but you don't decay right away. On forest floors, in swamps, and in bogs, high acidity or cold temperatures can dramatically slow decay. Go to **Nitrogen Reservoirs: Swamps and Leaf Litter!**

How did you arrive?

From a plant: Whether in the ocean or on land, animals can only get nitrogen from the plants they eat.

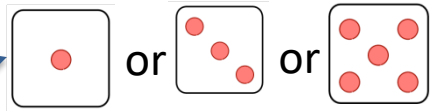
Where are you at?

Live Animals on land or in water

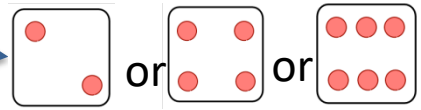
Nitrogen is essential for:

- All amino acids (used to make proteins like nails, hoofs, claws; and muscle
- DNA – nucleic acid
- Digestive enzymes
- Chlorophyll that plants require for photosynthesis

Where are you going?



The animal that you are within has died. Go to **dead plants and animals**.



Congratulations! The animal that you were within has excreted and you are in its waste. Go to **animal waste**!

How did you arrive?

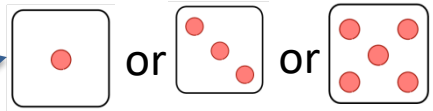
Underwater plants get their nitrogen directly from the water through specially adapted structures.

Where are you at?

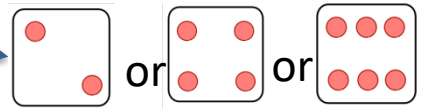
Ocean Plants

- 75% of the oxygen on the planet is created by phytoplankton, microscopic ocean plants.
- And they only do this in the top 300 feet!

Where are you going?



You die and sink to the bottom. Go to **Marine Sediments!**



An animal has eaten the plant that you are within! Go to **live animals**!

How did you arrive?

From a dead plant or animal

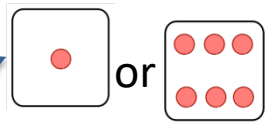
Where are you at?

Nitrogen Reservoir: Swamps and Leaf Litter

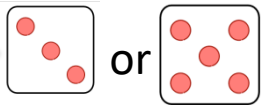
On forest floors, in swamps, and in bogs, high acidity or cold temperatures can dramatically slow decay.

A **reservoir** is an area that stores large quantities of Nitrogen short-term. Since it is a gas, Nitrogen cycles much faster than the Carbon Cycle

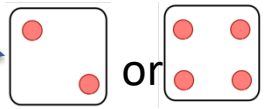
Where are you going?



You are preserved in a National Park. You get to **stay here!**



Uh-oh! The swamp has been drained to develop 100 new houses! You are released back to the **atmosphere!**



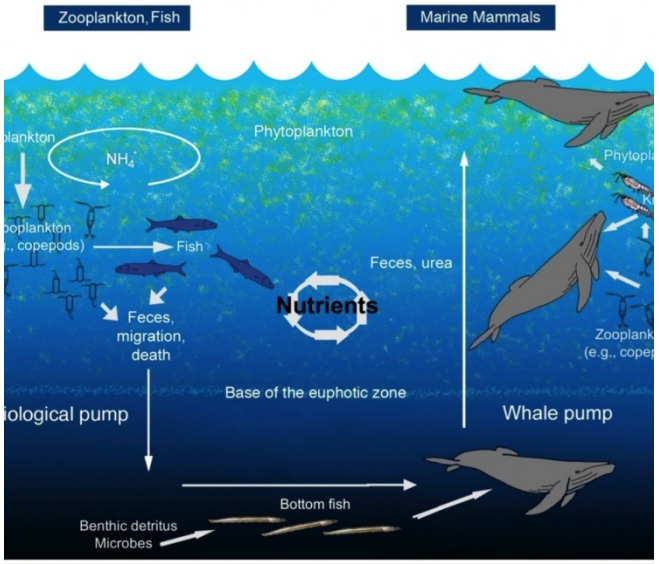
Oh, no! Your forest was cut down! You are released to **the atmosphere!**

How did you arrive?

When organisms in the ocean die, they can sink to the bottom, where the nitrogen becomes buried for a long period of time.

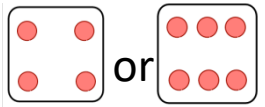
a **sink** is a reservoir that takes in more nitrogen than it releases. Nitrogen normally cycles quickly, this is one of the few places it gets trapped.

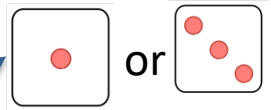
Where are you at?



Nitrogen Sink: Marine sediments

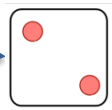
Where are you going?





You are still in the sink. **Roll Again**

You gradually turn into sedimentary rock, then are uplifted to dry land. Go to **Nitrogen Sink: Sedimentary rock and desert soil**



A volcanic eruption spews you into the atmosphere, where you combine with another nitrogen atom to form N2. Go to **Atmosphere**

How did you arrive?

Some nitrogen-containing compounds fall to the ocean floor as sediment. Over long periods of time, the sediments get compressed and form sedimentary rock. Eventually, geological uplift may move the sedimentary rock to land.

Nitrogen Fixation: (atmospheric N_2 is converted to forms plants can use through either abiotic or biotic pathways

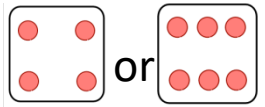
Cyanobacteria, algae, lichens, mosses, and liverworts form living crusts on many desert soils. These organisms can **fix** nitrogen from the atmosphere into ammonium in the soil.

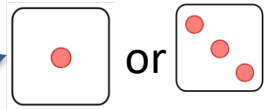
a **sink** is a reservoir that takes in more nitrogen than it releases

Where are you at?

Nitrogen Sink: Sedimentary rock and desert soil

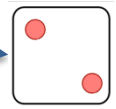
Where are you going?





You are still in the sink. **Roll Again**

Desert soils are being mined for nitrogen for artificial fertilizer. Go to **Artificial Fertilizer**



When the rock weathers, or is washed away, the ammonium becomes available to plants. Go to **Soil Ammonium**

How did you arrive?

You were in sedimentary rock. You were mined to make artificial fertilizer.

The atmosphere: the Haber-Bosch process captures nitrogen from the air to make synthetic fertilizer for crops.

You were part of a desert living crust and were mined to make artificial fertilizer.

A typical artificial fertilizer is 12% nitrogen

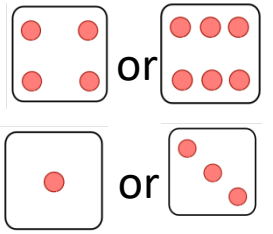
Where are you at?

Artificial Fertilizer

Artificial fertilizers are man-made chemical compounds that mimic the soil's natural minerals and elements to maximize plant growth.

Excess nitrogen from manure, sewage, or fertilizer runoff can cause algal blooms, which bring in more bacteria as algal decomposes, decreasing the oxygen in aquatic environment, often resulting in fish kills. Nitrogen is a LIMITING NUTRIENT, so Nature limits it naturally, and too much can be an issue.

Where are you going?



You are just the sort of nitrogen that plants need to live. You are now within a **live plant**!

Too much was applied. There was runoff and you ended up in the ocean, causing algal blooms that killed thousands of fish! Go to **Ocean**

Too much was applied, and some ran off into freshwater streams or lakes, causing exploding growth of water-plants. This clogs waterways and can lead to eutrophication. Go to **surface water.**

- Use the nitrogen cycle.pdf for student worksheet
- How many stops can you make on your trip?
- Will your journey ever end?
- Was everyone's journey the same? Why not?
- What would happen if a farmer used too much fertilizer? (In this game, that would mean that everyone starts from the fertilizer station at the same time.)
- What would happen if we burned too many fossil fuels?
- Livestock farming creates a large amount of animal waste. How would this affect the nitrogen cycle?
- **Assessment**
- Students write about their trip through the cycle including (1) where they went, and (2) how they got there.
- Show students a diagram of the nitrogen cycle. Ask them to create a diagram documenting only their journey