Biology Magnets Module 12: Carbon and Nitrogen Cycles

Teacher Information

This module uses magnets designed for teacher and student interaction to guide learning about the nitrogen and carbon cycles. Contained in this guide are outlines for lessons that can last from 10 minutes to approximately 60 minutes depending upon teacher preference. The lessons have both teacher-centered and student-centered activities. The student-centered activities are most effective if students are in small groups. It may be necessary to have multiple magnet sets for large classes. Student handouts are provided which can be printed out and given to each student group to help guide their progress as they work with the magnets. If budget or board space is limited, groups can alternate between using a set of magnets and doing other activities. Teachers can refer to the videos posted at the Biology Magnet web site at Biologymagnets.com for further teaching instructions.

Magnet Care and Maintenance

Biology magnets are made to last for years. Periodically magnets will fall off or are knocked off the plastic. A piece of magnetic tape is included with each module, which should be able to replace around 10-12 magnets if necessary. Simply cut a new magnet and peel off the back to replace. Magnetic tape can be purchased from a hobby store to replace magnets lost over time. Laminate may peel off, especially on small pieces. Use transparent tape to re-attach laminate that comes loose, curling the tape over the back of the magnet. The machines used to cut Biology magnets are not perfectly accurate. Sometimes a bit of white or black outline on the edges occurs or a cut might be slightly off center. Use scissors to remove extra outline that is unnecessary if desired. Note that white outline virtually disappears from view when the magnets are on a white board. Store magnets in the clasp envelopes in which they arrived for easy organization.

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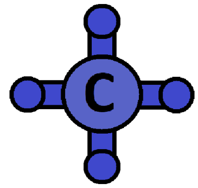
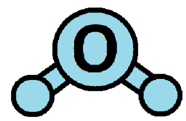
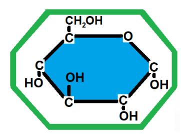
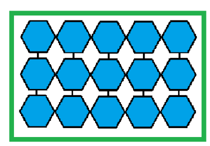
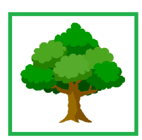
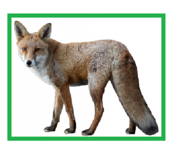
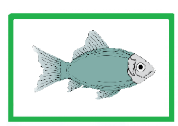
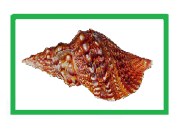
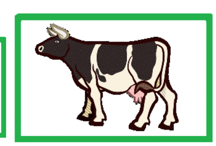
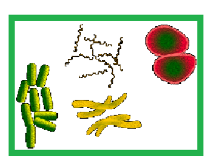
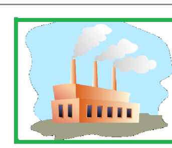
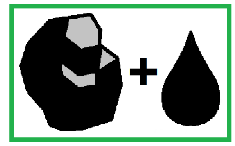
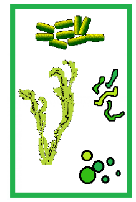
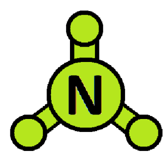
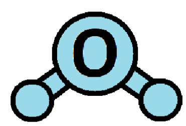
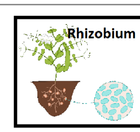
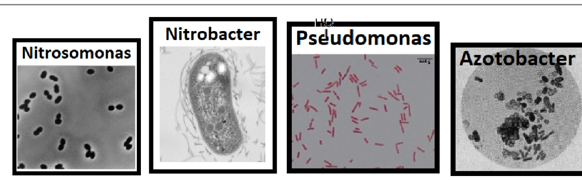
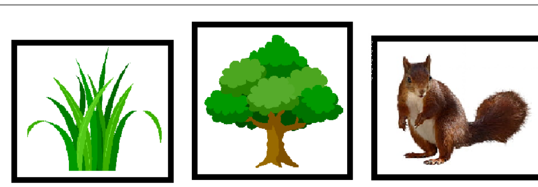
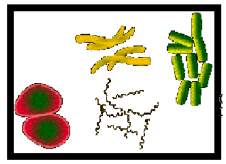
Module 12A – Carbon Cycle - Materials List

Magnet Name	Quantity	Picture
Carbon Atom	2	
Oxygen Atom	6	
Hydrogen Atom	12	
Calcium	1	
Glucose	4	
Polysaccharide	4	
Plants and Animals	6	      
Decomposers	2	 
Factory	1	

Fossil Fuels	1	
Algae	1	
Sediment Layers	1	
Volcano	1	
Sun	1	
Process Naming Plates	8	
3” Magnetic Tape Strip	1	
Total Pieces	52	

Module 12B – Nitrogen Cycle - Materials List

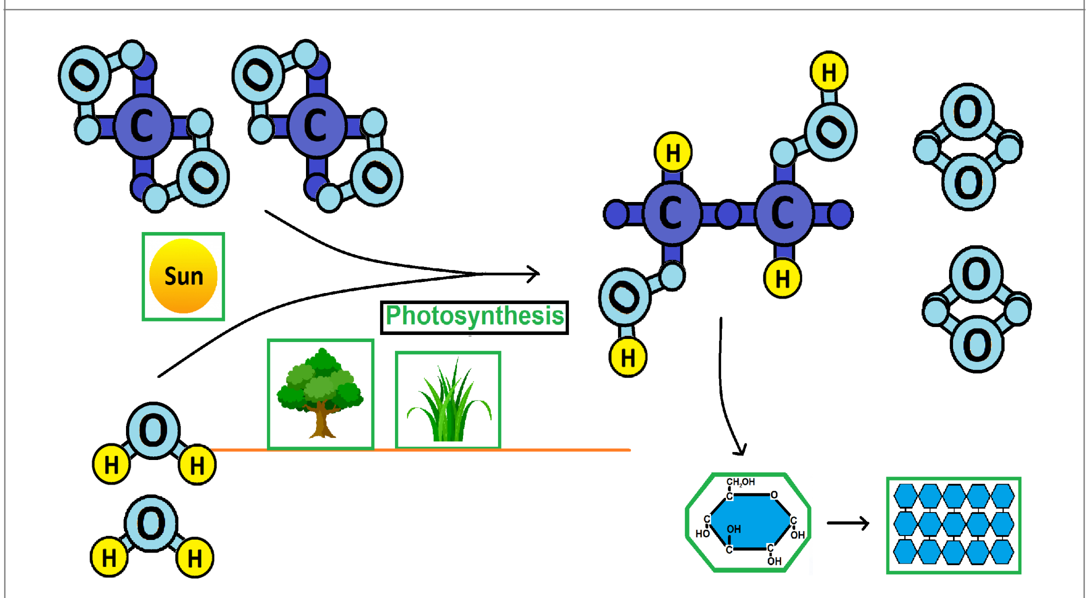
Magnet Name	Quantity	Picture
Nitrogen Atom	5	
Oxygen Atom	6	
Hydrogen Atom	15	
Rhizobium in Root Nodules	1	
Nitrogen Cycling Bacteria	4	
Plants and Animals	3	

Decomposers	2	 
Lightning	1	
Process Naming Plates	6	**Nitrification**
Total Pieces	43	

Lesson 12A – Carbon Cycle (10-60 minutes)

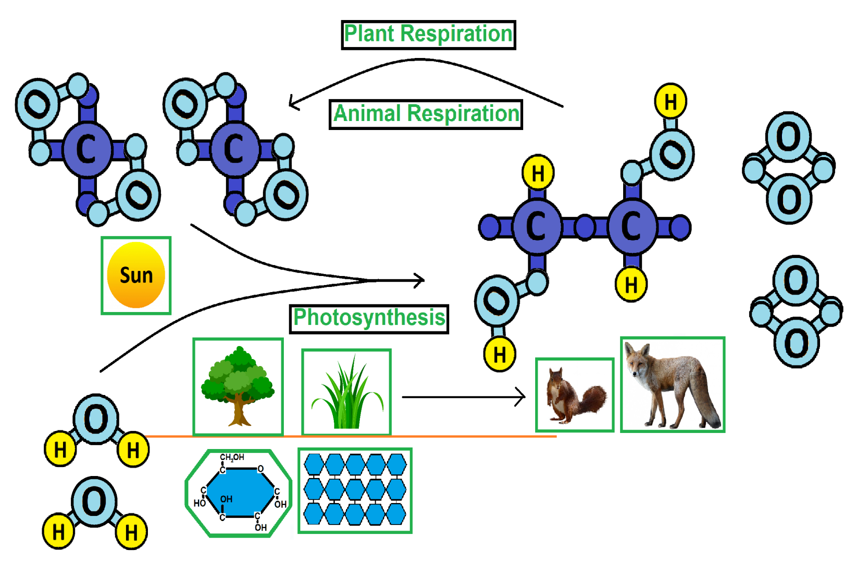
Teacher-Centered Activity (10-30 minutes): Carbon Cycle: This lesson reviews the carbon cycle using the Biology Magnets from Module 12 as shown in the table at the beginning. Start the lesson by demonstrating **carbon fixation**. Start with carbon dioxide (CO_2) in the atmosphere. Draw a line to represent the soil in order to differentiate between processes in the air and underground. Use the sun magnet and draw a line from the atmosphere to the plant magnets representing **photosynthesis**. Show this by breaking up the CO_2 and adding water to form the precursors of organic molecule, yielding oxygen (O_2) as a byproduct. Use the glucose and polysaccharide magnets to show how the fixed carbon is stored (**Figure 12.A.1**).

Figure 12.A.1 – Carbon Fixation Molecular Models

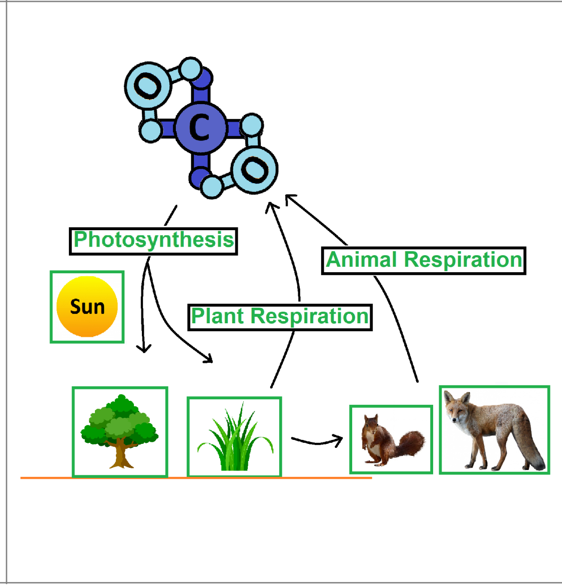


Plants and animals will perform **respiration** and convert the fixed carbon back to carbon dioxide and water. This can be shown molecularly by taking apart the molecules formed from photosynthesis to reproduce CO_2 and H_2O (**Figure 12.A.2**). If space is limited, the processes can be shown without using the molecular models (**Figure 12.A.3**).

Figure 12.A.2 – Photosynthesis/Respiration with Molecular Models

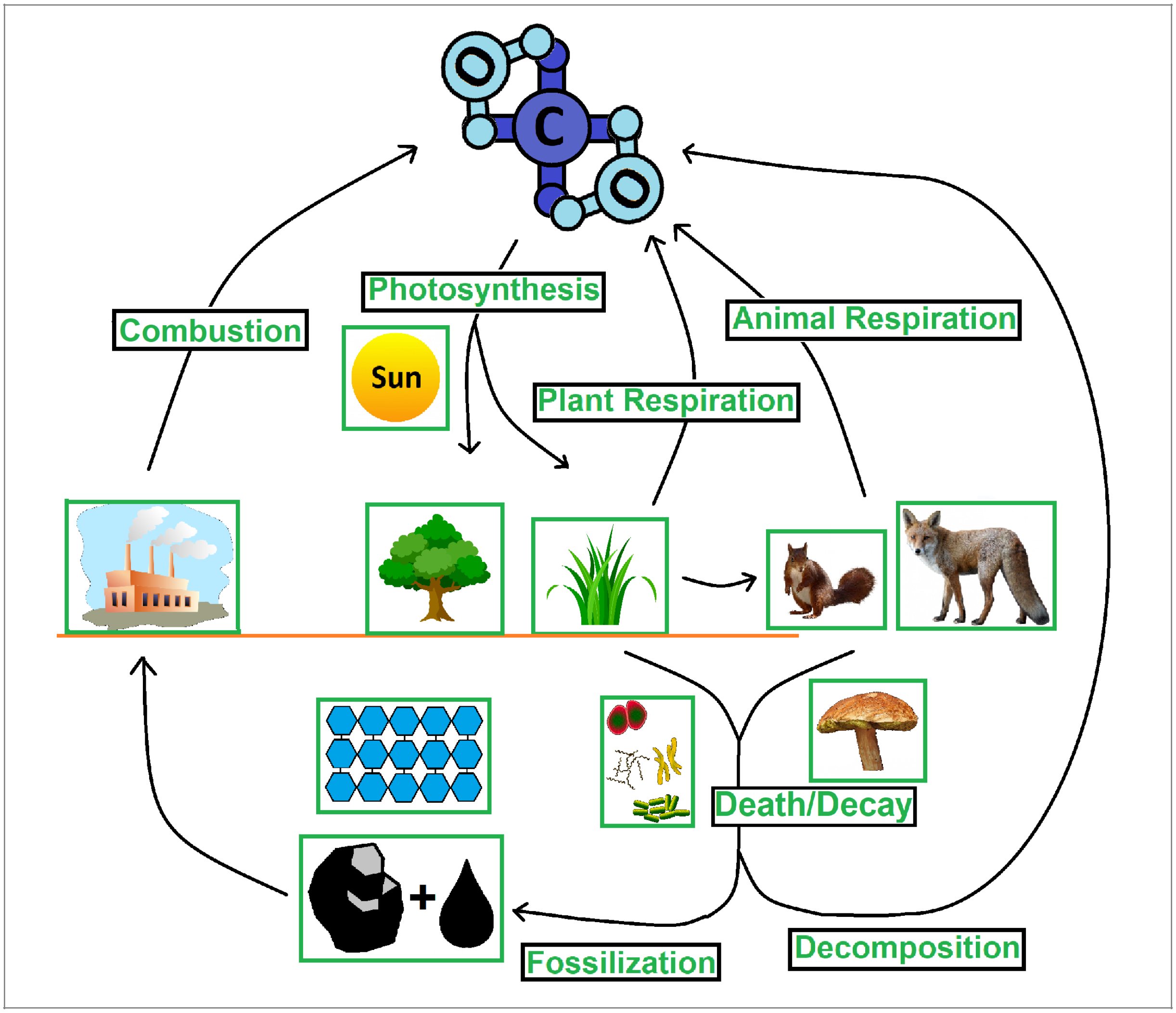


12.A.3 – Photosynthesis/Respiration



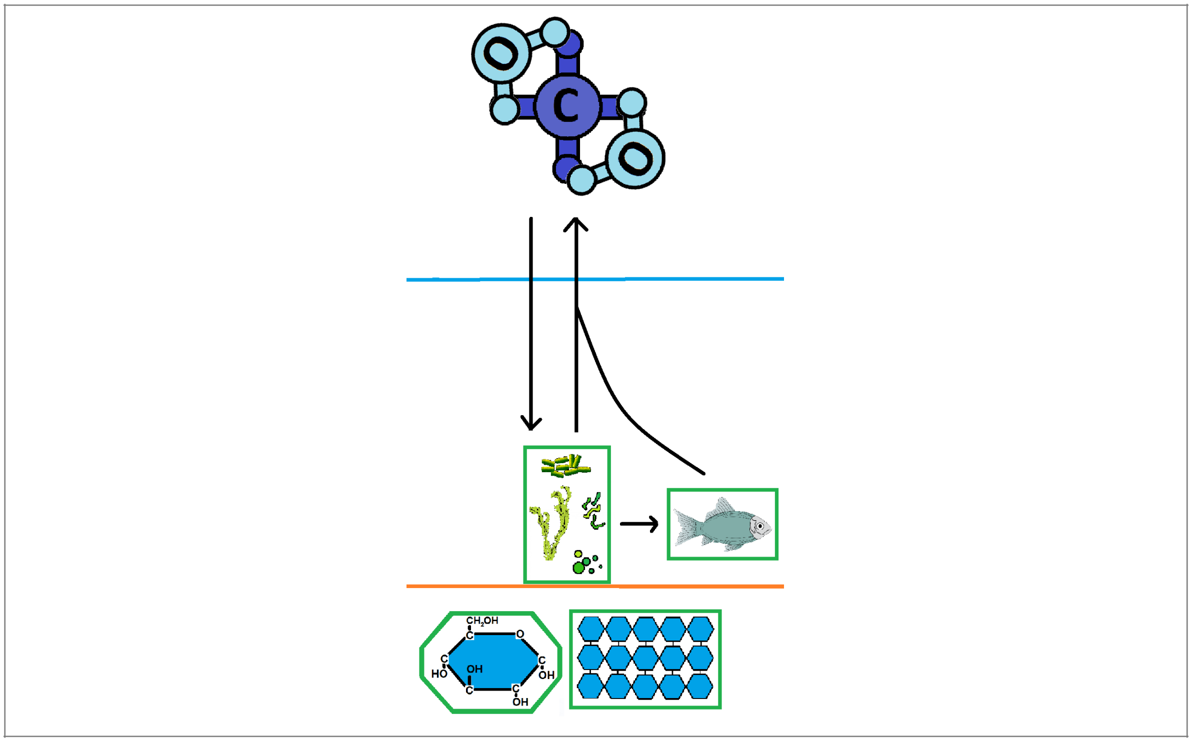
When plants and animals die, their bodies **decay** and **decompose**. Use the decomposers magnets and the process nameplates to show how decomposition can return CO2 to the atmosphere. If organic material is buried without decomposing, **fossilization** can occur. Use the fossil fuels and polysaccharide magnets to represent the fossil carbon pool. The fossil fuels are burned for energy by factories and for transportation. This process of **combustion** can return the CO2 back to the atmosphere. Demonstrate by using the factory magnet and combustion nameplate (**Figure 12.A.4**).

Figure 12.A.4 – Decomposition and Fossilization



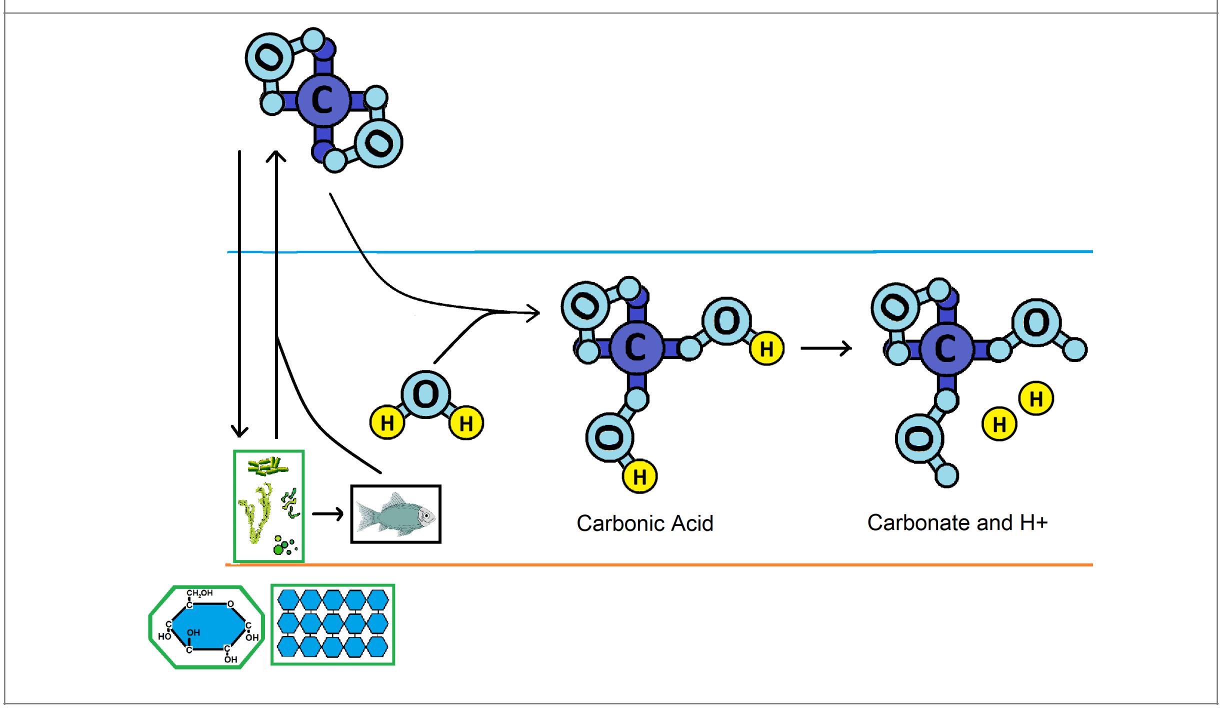
Oceanic Carbon Cycle: Use the algae and fish magnets to show the photosynthesis and fixation of carbon dioxide to produce glucose and polysaccharides in plants, which are then eaten by animals. Animals and plants will in turn produce carbon dioxide through the process of respiration (**Figure 12.A.5**).

Figure 12.A.5 – Carbon Cycling in the Ocean through Plants and Animals



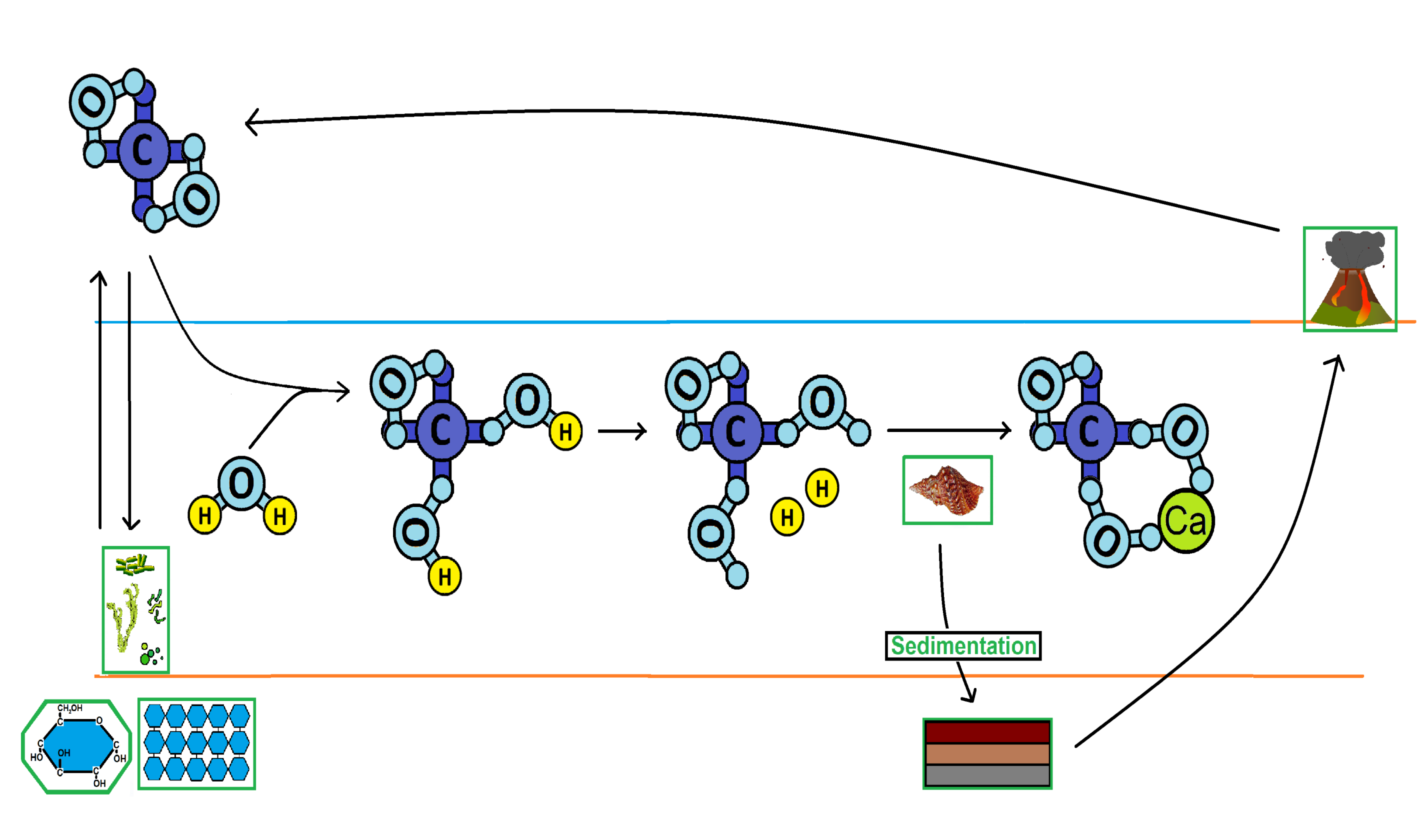
Show the formation of carbonic acid and ocean acidification by combining a CO_2 with an H_2O to make carbonic acid (H_2CO_3). The Carbonic acid will then disassociate to form carbonate and H^+. The H^+ ions make the pH of the water lower, which is the main contributor to ocean acidification (**Figure 12.A.6**).

Figure 12.A.6 – Carbon Cycling in the Ocean through Plants and Animals



The carbonate can be used by organisms such as mollusks, coral, and foraminifera to form shells made of calcium carbonate. Use the mollusk magnet and combine the carbonate magnets with the calcium magnet to form calcium carbonate. Use the sediment layers and **sedimentation** name plate magnet to show how the shells can build up over time at the bottom of the ocean. That carbon can be released when plates of the ocean floor move back into the earth via plate tectonics, heating up the carbon that rises to form volcanoes, and releases the CO_2 back to the atmosphere (**Figure 12.A.7**).

Figure 12.A.7 – Oceanic Carbon Cycle



Extra exercises:

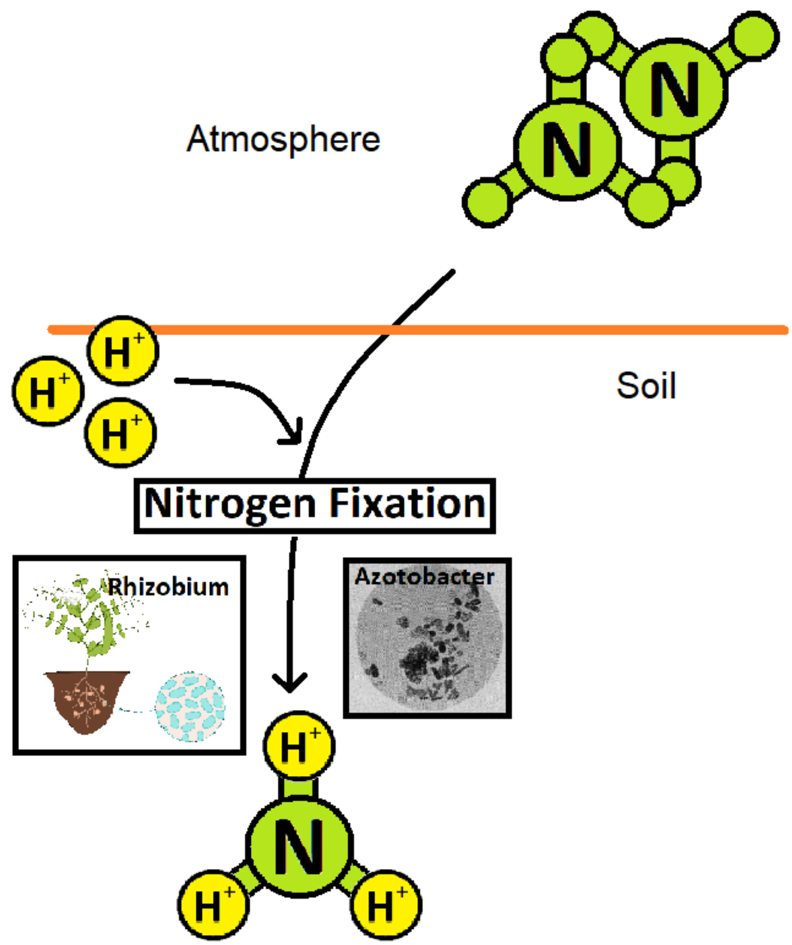
Relative amounts of carbon: Using the internet for research, have students find the relative amounts of carbon stored in each pool and moving through each process. Which processes are the most important to the carbon cycle and would have the largest effect if disrupted? To which processes are humans contributing in the largest amounts?

Global Warming/Climate Change: Have students research global warming and find out which parts of the carbon cycle are changing due to human activity. Students can use the magnets to build methane (CH_4) and discuss its formation and contribution to the cycle. A cow magnet is included which can be used to represent livestock contribution of methane to the atmosphere. Students can use index cards and magnetic tape to make other magnets to represent carbon contributions from other sources (e.g. fires, cars).

Lesson 12B – Nitrogen Cycle (10-60 minutes)

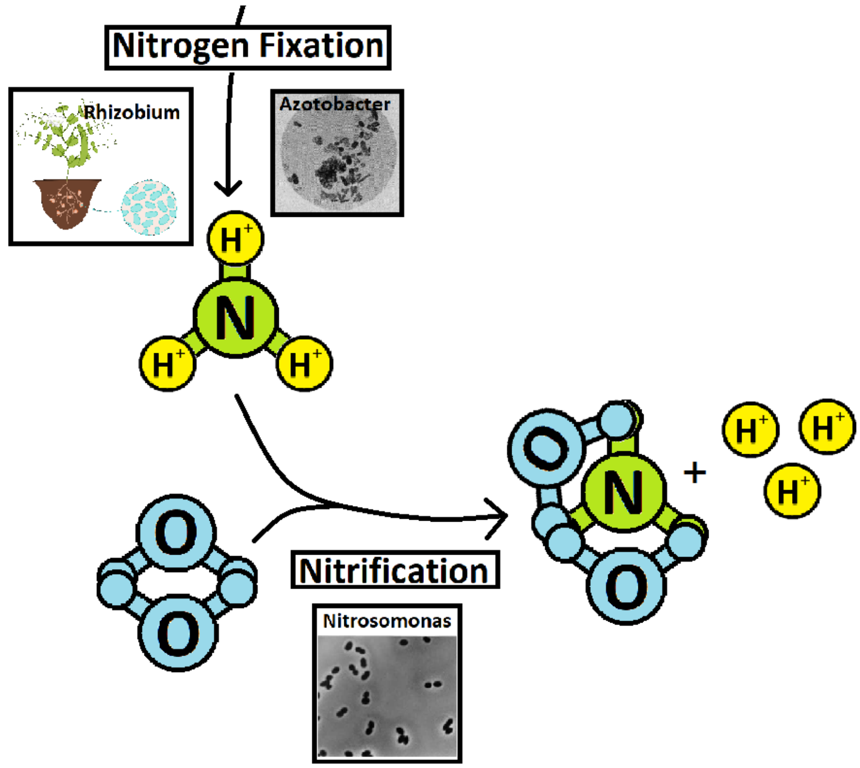
Teacher-Centered Activity (10-30 minutes): Nitrogen Cycle: This lesson reviews the nitrogen cycle using the Biology Magnets from Module 12 as shown in the table above. Start the lesson with nitrogen (N_2) in the atmosphere. Draw a line to represent the soil to differentiate between processes in the air and underground. Draw a line from the atmosphere to the soil representing **nitrogen fixation**, breaking up the N_2 and adding hydrogen ions to form ammonia (NH_3). Use the *Rhizobium* and *Azotobacter* magnets to show the bacteria that perform nitrogen fixation (**Figure 12.B.1**).

Figure 12.B.1 – Nitrogen Fixation



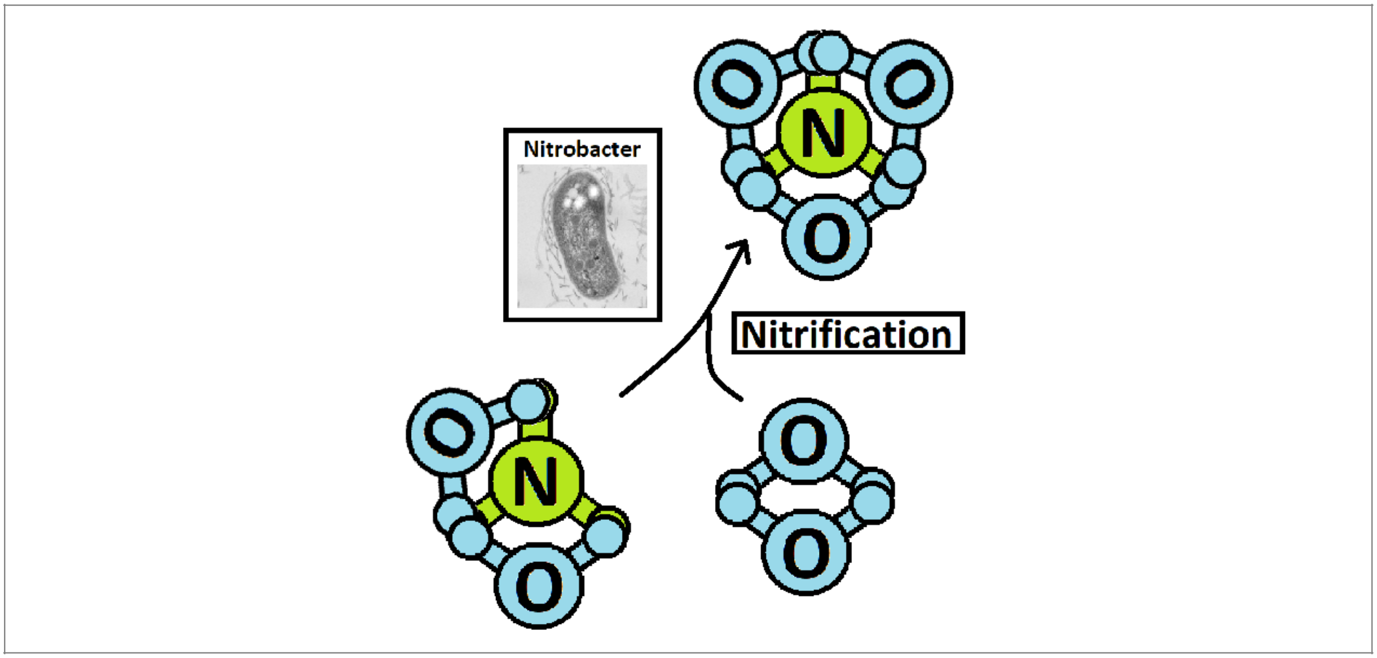
Next, demonstrate the first **nitrification** step by adding a molecule of oxygen from the soil to the ammonia and removing the hydrogen ions to form nitrite (NO_2). This nitrification is often performed by the *Nitrosomonas* bacterium. Use the *Nitrosomonas* and Nitrification nameplate magnets to highlight the process (**Figure 10.B.2**)

Figure 12.B.2 – Nitrification Step 1

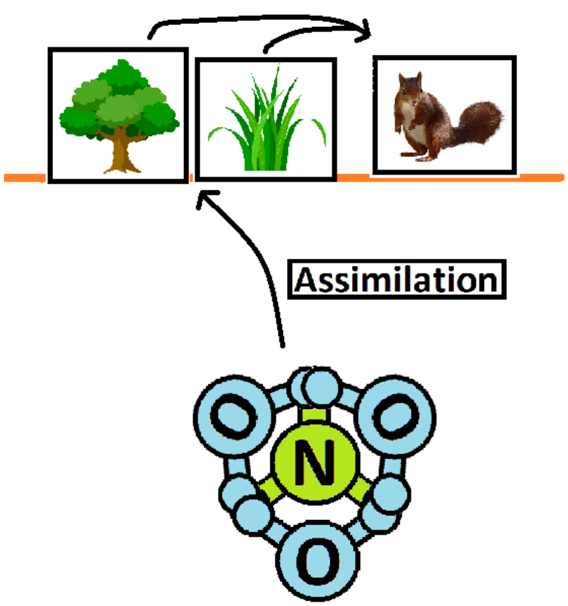
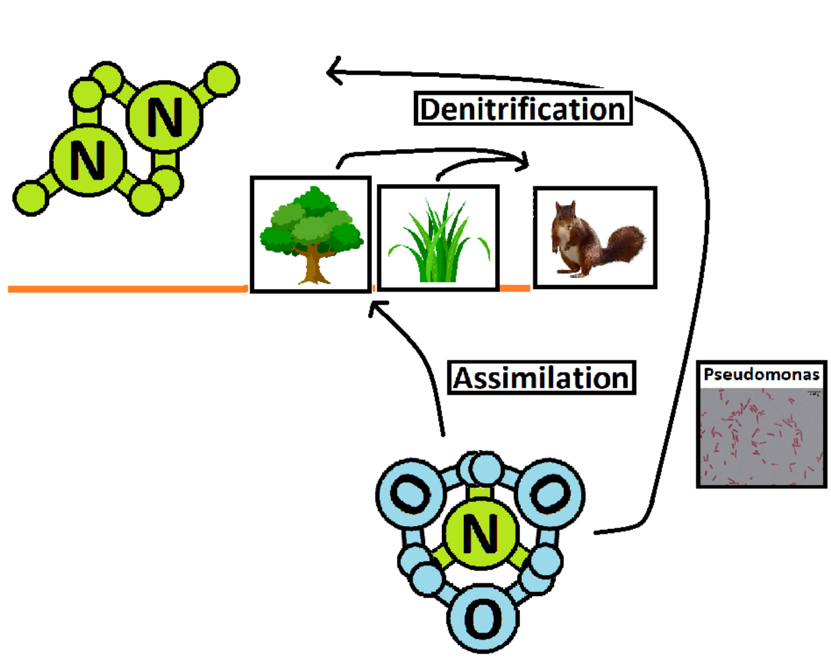


The next **nitrification** step can be shown by using another oxygen molecule that is broken apart and one more oxygen is added to the nitrite to make nitrate (NO_3). *Nitrobacter* is a soil bacterium that can perform this step. (**Figure 10.A.3**).

Figure 10.B.3 – Nitrification Step 2

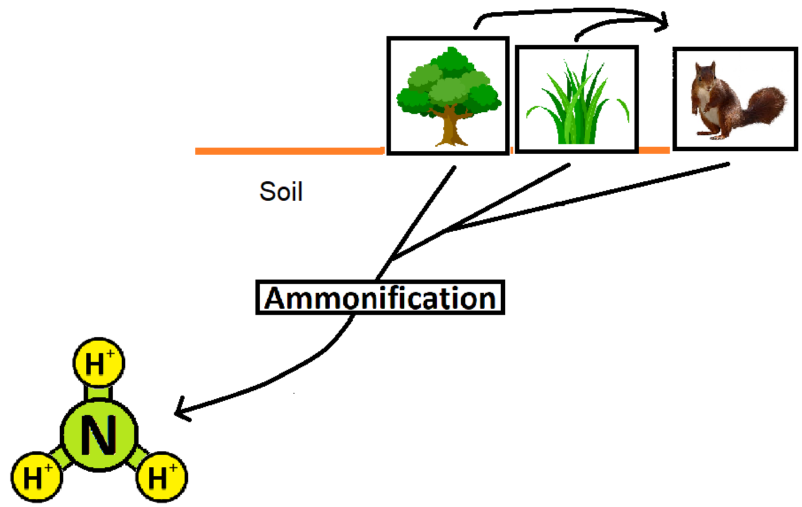


In the **assimilation** step, the nitrate (NO_3) is absorbed by plants and used to make organic molecules such as proteins and nucleic acids. Animals eat the plants to obtain the nitrogen and organic molecules. Use the plant and animal magnets and draw lines to show this step. Note that the plants and animals can be placed above ground level **(figure 12.B.4)**. The **denitrification** process can also be shown here. Draw a line from the nitrate back to the N_2 in the atmosphere. Denitrification is sometimes performed by the Pseudomonas bacteria to obtain oxygen in oxygen depleted soils. Use the Pseudomonas and denitrification magnets along the line drawn for denitrification **(figure 10.B.5)**.

Figure 12.B.4 – Assimilation	**Figure 10.B.5 – Denitrification**
	

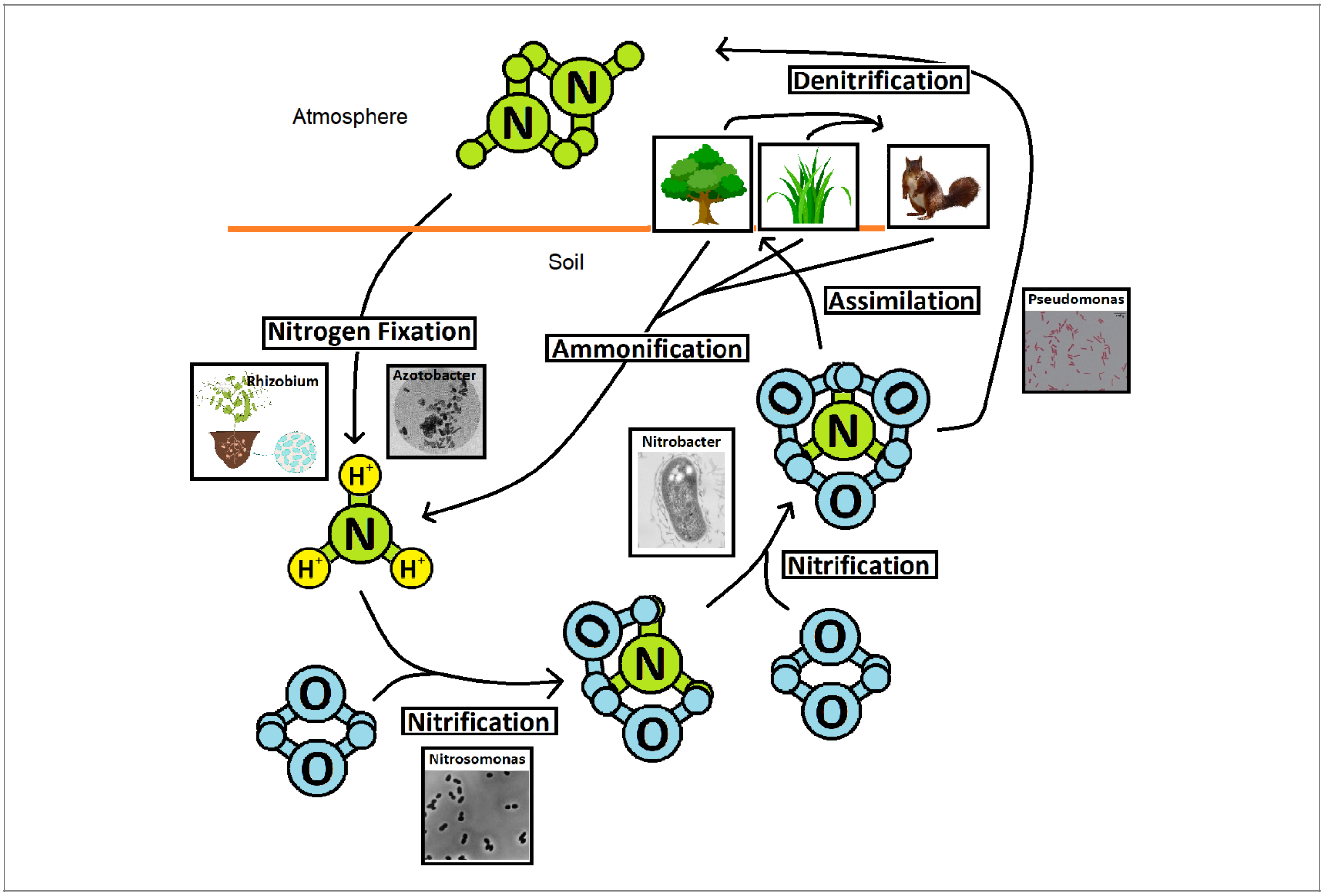
The dead and decaying bodies and wastes of plants and animals are converted back into ammonia (NH3) by a process called **ammonification**. This can be demonstrated by drawing lines connecting the plant and animal magnets back to the ammonia magnets formed in the first step, nitrogen fixation. Use the ammonification magnet to demonstrate this step **(figure 10.B.6)**.

Figure 10.B.6 – Ammonification



The entire process of the nitrogen cycle is shown below **(figure 10.B.7).** Go over the steps again, removing the magnets with the names of the processes and placing them as you describe each step. See if the students can recall the names of each process before placing the process nameplate magnets.

Figure 10.B.7 – The Nitrogen Cycle



Student Centered Activity (10-30 minutes): After teaching the structures, put students into small groups. A copy of the student guide for the nitrogen cycle may be given to each group if necessary. Have them take turns setting up the nitrogen cycle from scratch and showing each step starting from N_2 in the atmosphere. Allow the students to correct and help one another. After they have achieved proficiency, have them try to do the cycle without the process name magnets and instead write the process names next to the arrows from memory.

Extra exercises:

Details of the nitrogen cycle: The nitrogen cycle is more involved than has been shown thus far. Lightning, fertilizer production, factory emissions and other forms of combustion contribute to the nitrogen in the cycle. Demonstrate these factors using the appropriate magnets supplied with the kit.

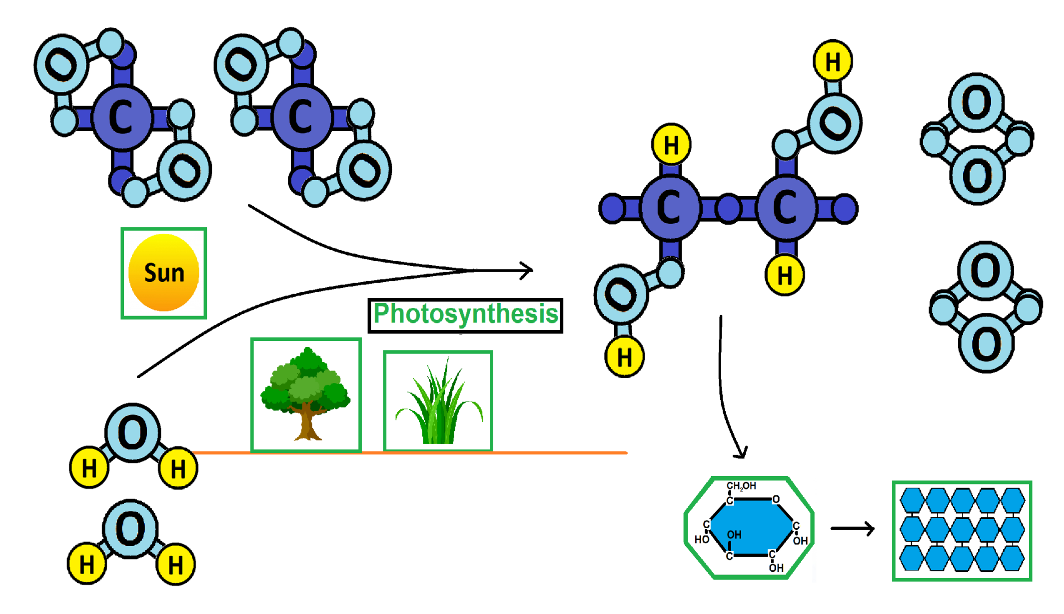
Marine nitrogen cycle: Have students research and discuss how nitrogen cycles in marine (ocean) ecosystems. Make magnets out of index cards and magnetic tape to represent algae, fish, and sediment to show the movement of nitrogen through the marine ecosystem.

Relative amounts of nitrogen: Using the internet for research, have students find the relative amounts of nitrogen stored in each pool and moving through each process. Which processes are the most important to the nitrogen cycle and would have the largest effect if disrupted? To which processes are humans contributing in the largest amounts?

Lesson 12A – Carbon Cycle – Student Guide

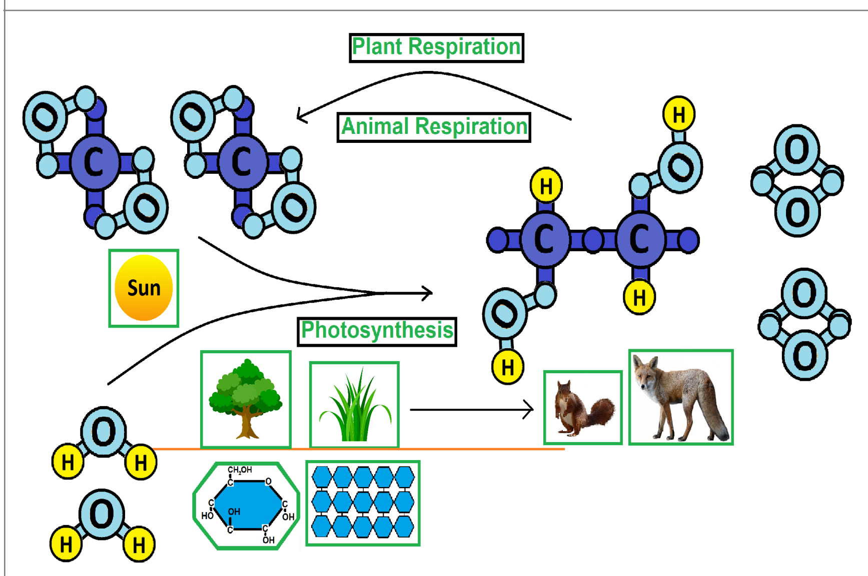
Start the lesson by demonstrating **carbon fixation**. Start with carbon dioxide (CO_2) in the atmosphere. Draw a line to represent the soil in order to differentiate between processes in the air and underground. Use the sun magnet and draw a line from the atmosphere to the plant magnets representing **photosynthesis**. Show this by breaking up the CO_2 and adding water to form the precursors of organic molecule, yielding oxygen (O_2) as a byproduct. Use the glucose and polysaccharide magnets to show how the fixed carbon is stored (**Figure 12.A.1**).

Figure 12.A.1 – Carbon Fixation Molecular Models

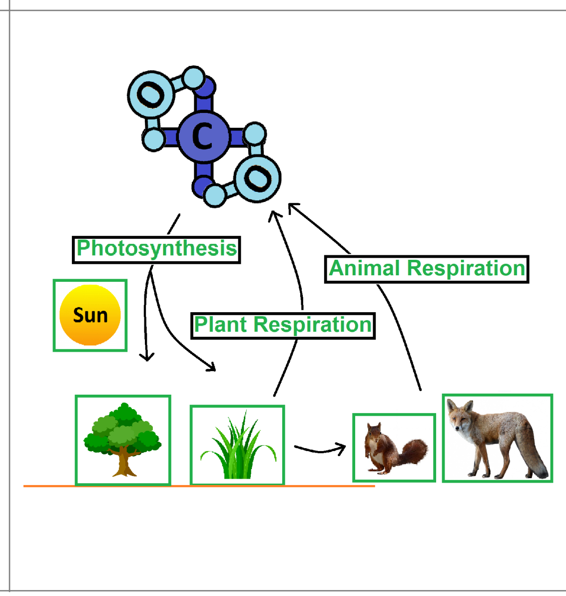


Plants and animals will perform **respiration** and convert the fixed carbon back to carbon dioxide and water. This can be shown molecularly by taking apart the molecules formed from photosynthesis to reproduce CO_2 and H_2O (**Figure 12.A.2**). If space is limited, the processes can be shown without using the molecular models (**Figure 12.A.3**).

Figure 12.A.2 – Photosynthesis/Respiration with Molecular Models

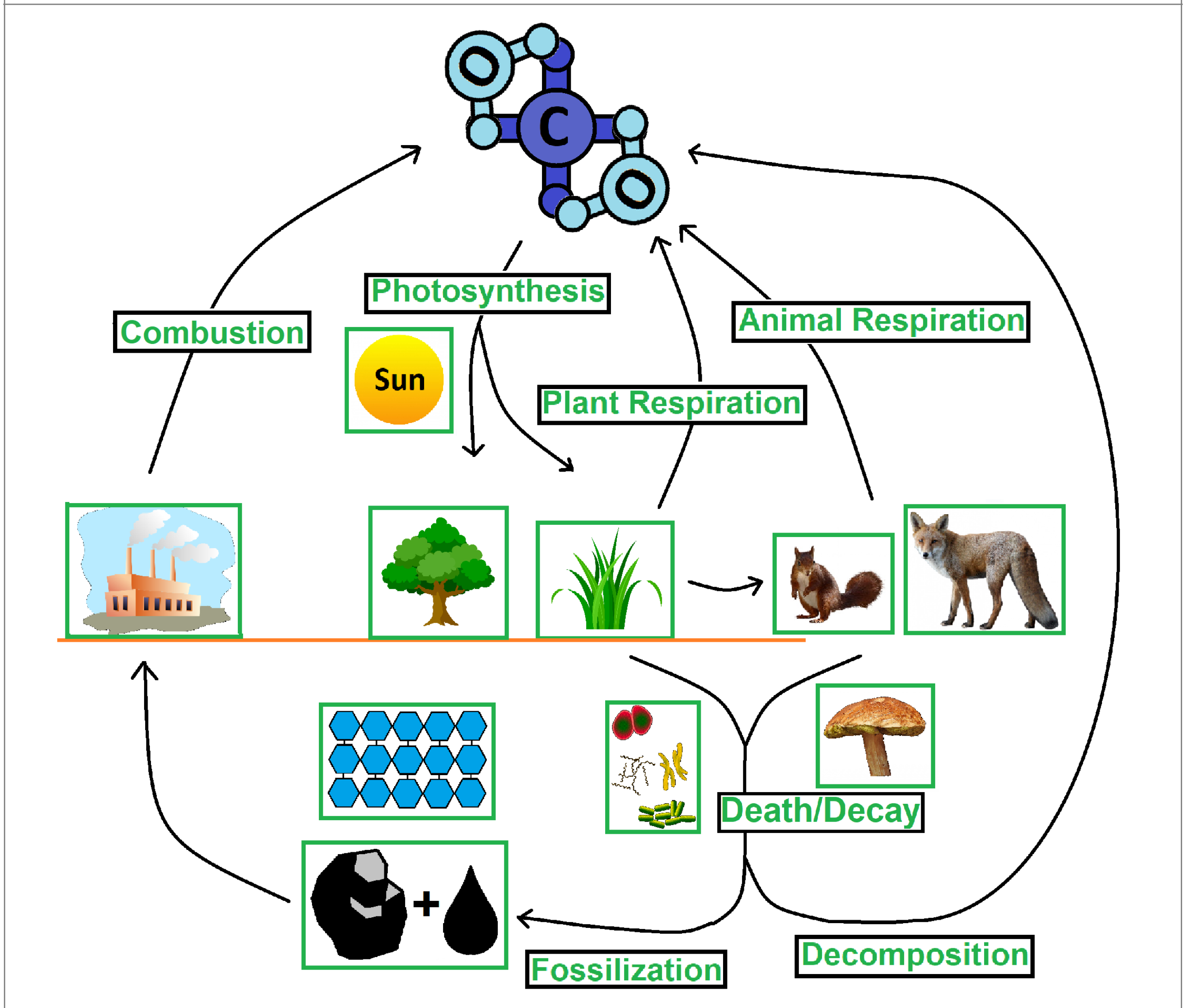


12.A.3 – Photosynthesis/Respiration



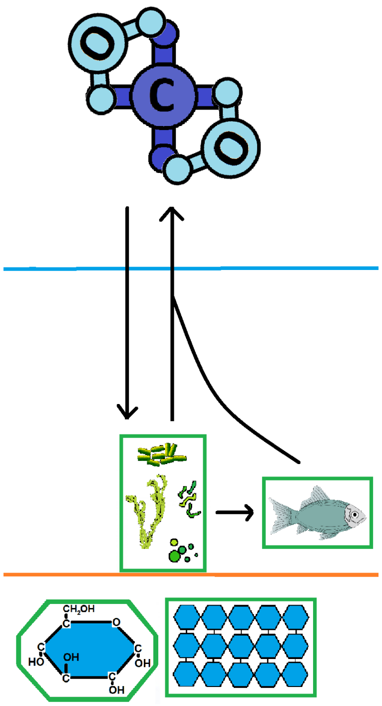
When plants and animals die, their bodies **decay** and **decompose**. Use the decomposers magnets and the process nameplates to show how decomposition can return CO2 to the atmosphere. If organic material is buried without decomposing, **fossilization** can occur. Use the fossil fuels and polysaccharide magnets to represent the fossil carbon pool. The fossil fuels are burned for energy by factories and for transportation. This process of **combustion** can return the CO2 back to the atmosphere. Demonstrate by using the factory magnet and combustion nameplate (**Figure 12.A.4**).

Figure 12.A.4 – Decomposition and Fossilization



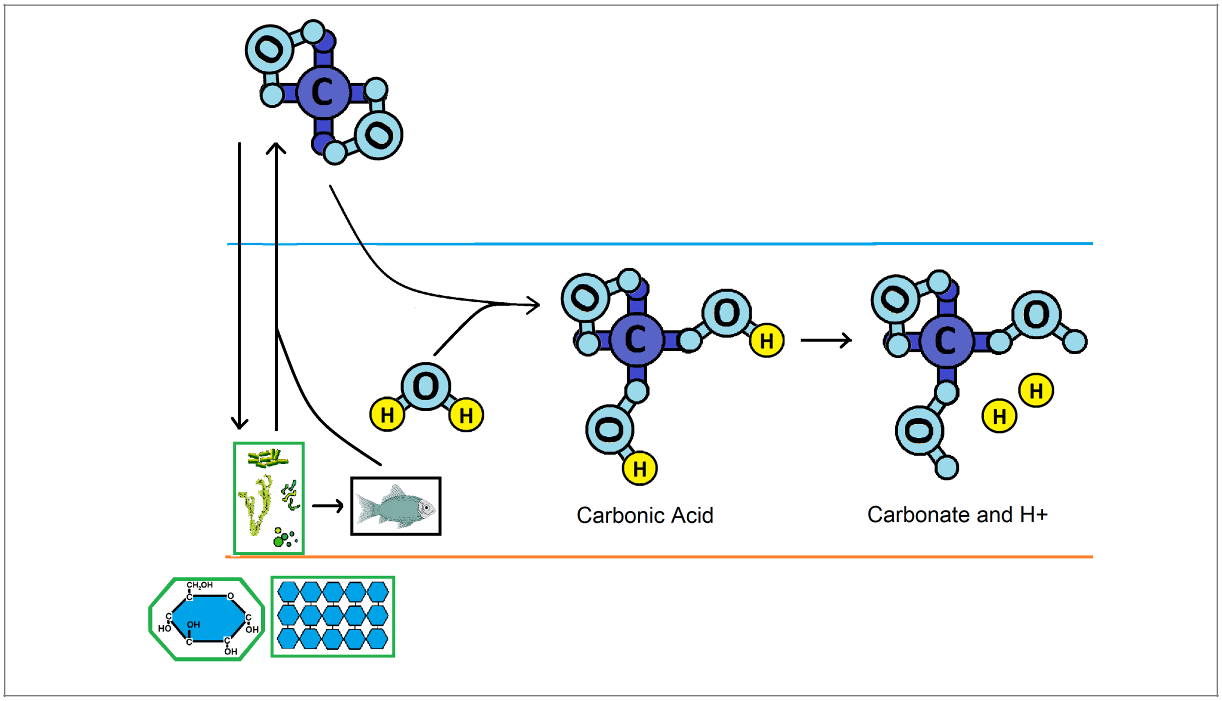
Oceanic Carbon Cycle: Use the algae and fish magnets to show the photosynthesis and fixation of carbon dioxide to produce glucose and polysaccharides in plants, which are then eaten by animals. Animals and plants will in turn produce carbon dioxide through the process of respiration (**Figure 12.A.5**).

Figure 12.A.5 – Carbon Cycling in the Ocean through Plants and Animals



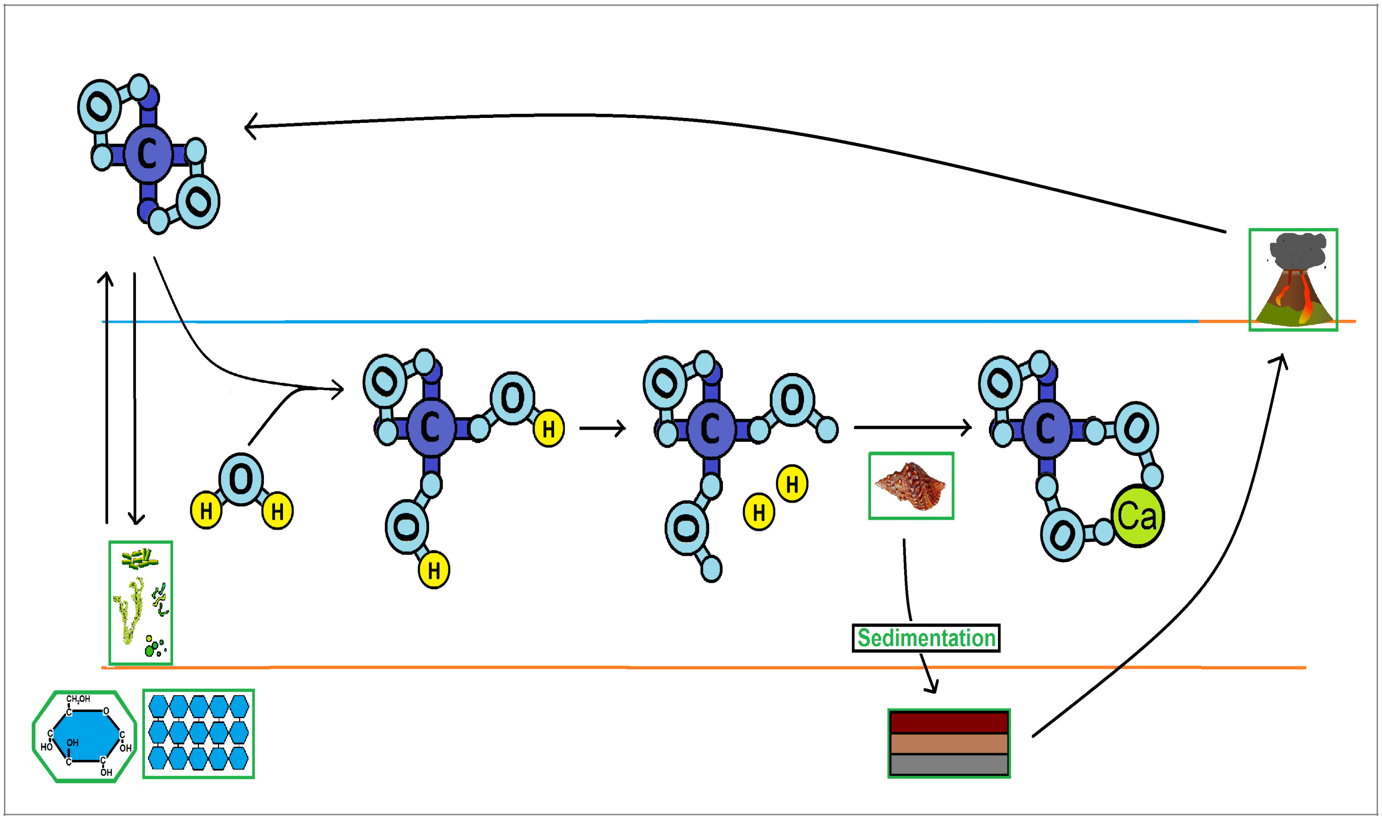
Show the formation of carbonic acid and ocean acidification by combining a CO_2 with an H_2O to make carbonic acid (H_2CO_3). The Carbonic acid will then disassociate to form carbonate and H^+. The H^+ ions make the pH of the water lower, which is the main contributor to ocean acidification (**Figure 12.A.6**).

Figure 12.A.6 – Carbon Cycling in the Ocean through Plants and Animals



The carbonate can be used by organisms such as mollusks, coral, and foraminifera to form shells made of calcium carbonate. Use the mollusk magnet and combine the carbonate magnets with the calcium magnet to form calcium carbonate. Use the sediment layers and **sedimentation** name plate magnet to show how the shells can build up over time at the bottom of the ocean. That carbon can be released when plates of the ocean floor move back into the earth via plate tectonics, heating up the carbon that rises to form volcanoes, and releases the CO_2 back to the atmosphere (**Figure 12.A.7**).

Figure 12.A.7 – Oceanic Carbon Cycle



Extra exercises:

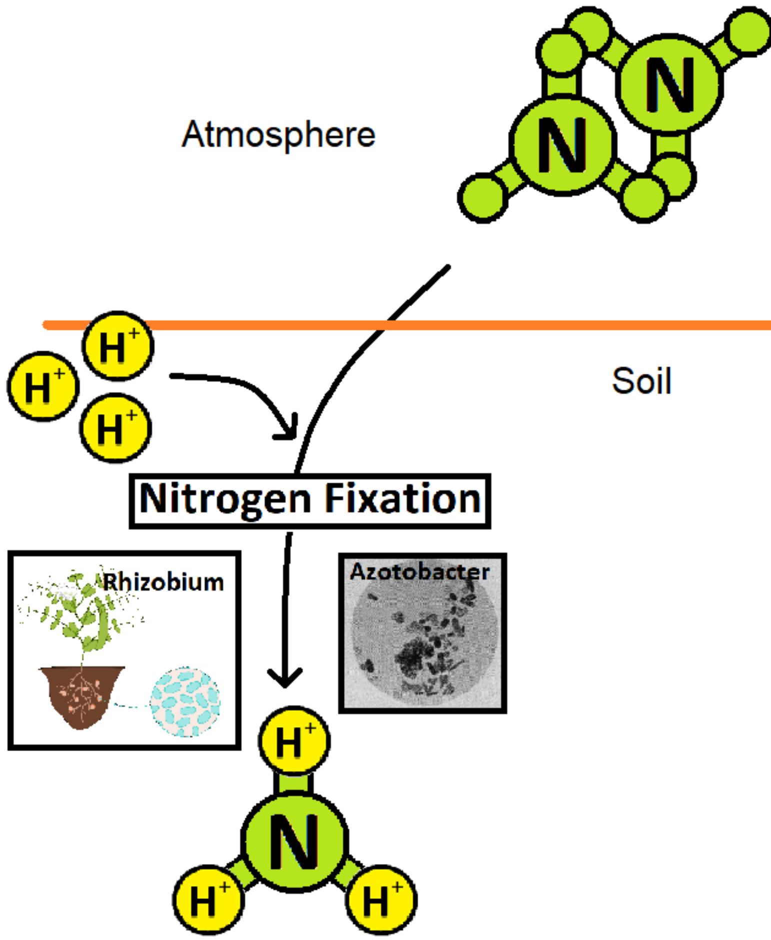
Relative amounts of carbon: Using the internet for research, find the relative amounts of carbon stored in each pool and moving through each process. Which processes are the most important to the carbon cycle and would have the largest effect if disrupted? To which processes are humans contributing in the largest amounts?

Global Warming/Climate Change: Research global warming and find out which parts of the carbon cycle are changing due to human activity. Students can use the magnets to build methane (CH_4) and discuss its formation and contribution to the cycle. A cow magnet is included which can be used to represent livestock contribution of methane to the atmosphere. Students can use index cards and magnetic tape to make other magnets to represent carbon contributions from other sources (e.g. fires, cars, permafrost).

Lesson 12B – Nitrogen Cycle – Student Guide

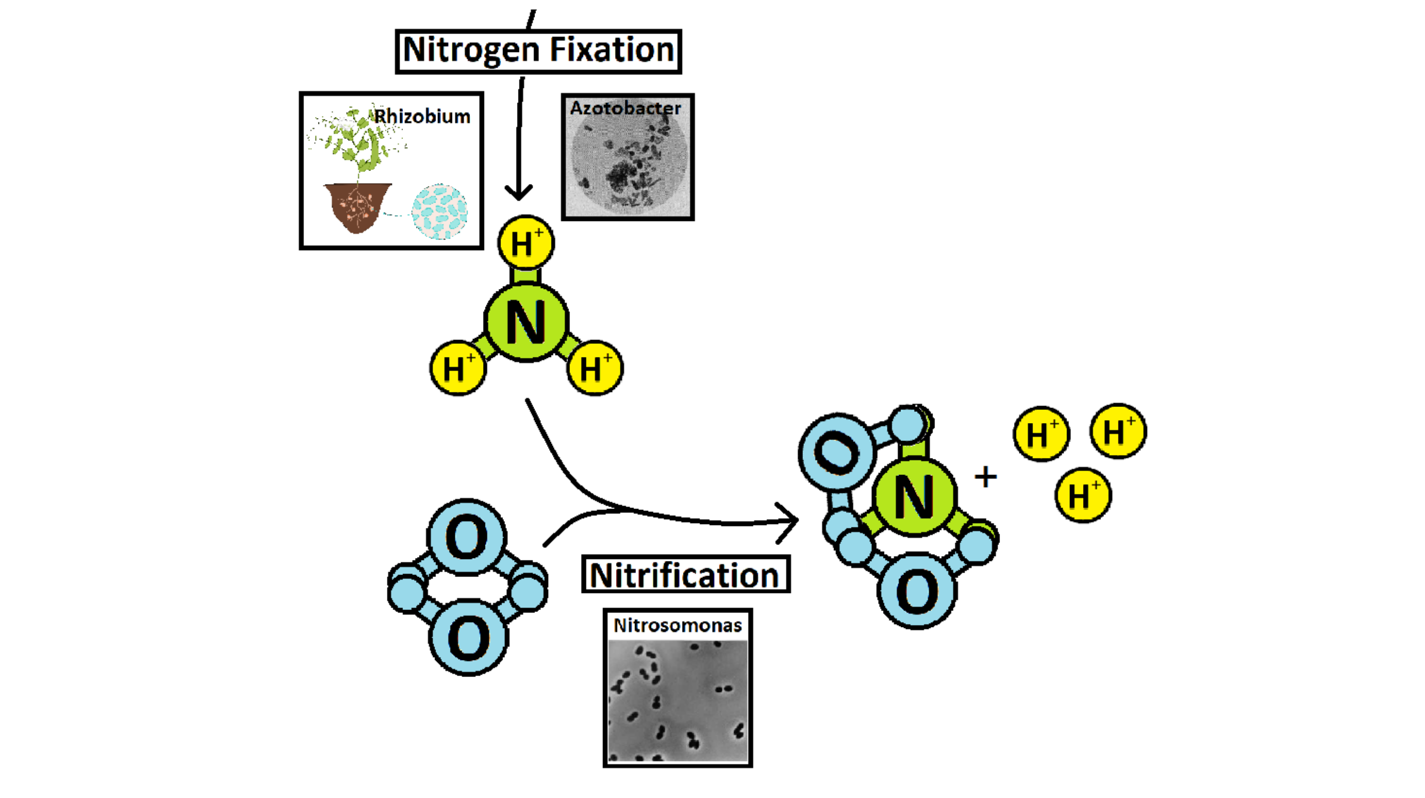
Start with nitrogen (N_2) in the atmosphere. Draw a line to represent the soil to differentiate between processes in the air and underground. Draw a line from the atmosphere to the soil representing **nitrogen fixation**, breaking up the N_2 and adding hydrogen ions to form ammonia (NH_3). Use the *Rhizobium* and *Azotobacter* magnets to show the bacteria that perform nitrogen fixation (**Figure 12.B.1**).

Figure 12.B.1 – Nitrogen Fixation



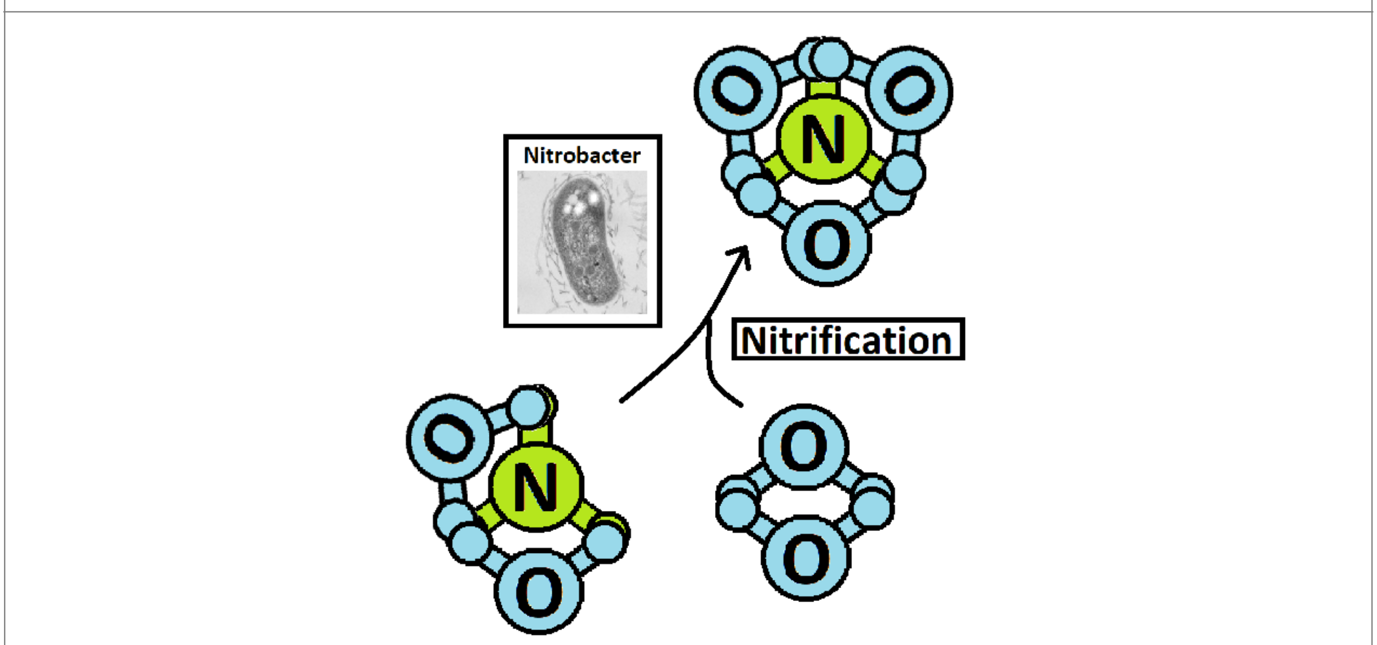
Next, demonstrate the first **nitrification** step by adding a molecule of oxygen from the soil to the ammonia and removing the hydrogen ions to form nitrite (NO_2). This nitrification is often performed by the *Nitrosomonas* bacterium. Use the *Nitrosomonas* and Nitrification nameplate magnets to highlight the process (**Figure 10.B.2**)

Figure 12.B.2 – Nitrification Step 1

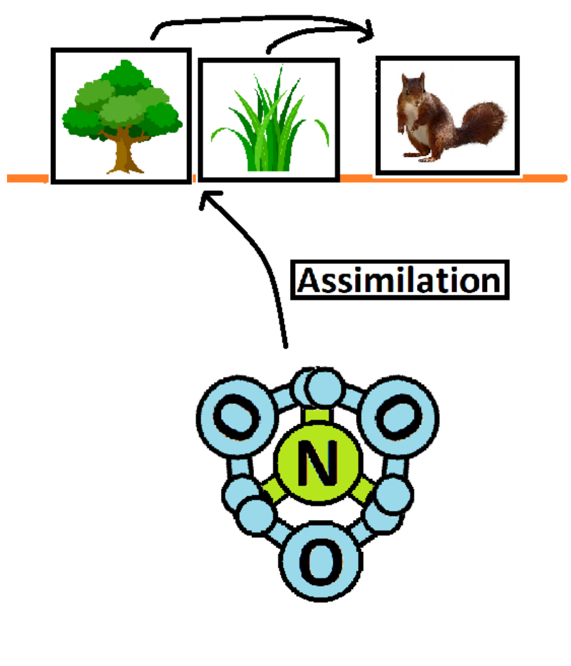
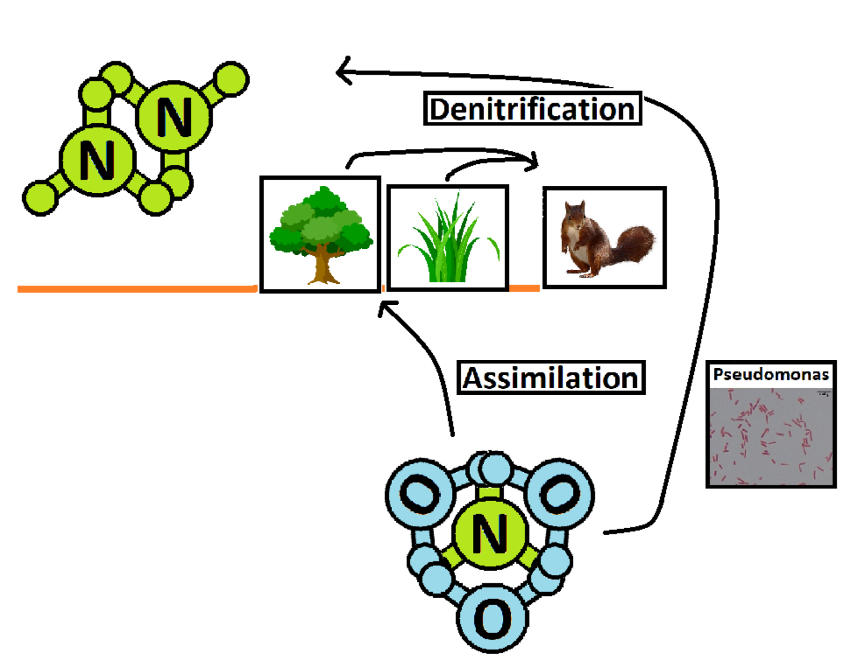


The next **nitrification** step can be shown by using another oxygen molecule that is broken apart and one more oxygen is added to the nitrite to make nitrate (NO_3). *Nitrobacter* is a soil bacterium that can perform this step. (**Figure 10.B.3**).

Figure 10.B.3 – Nitrification Step 2

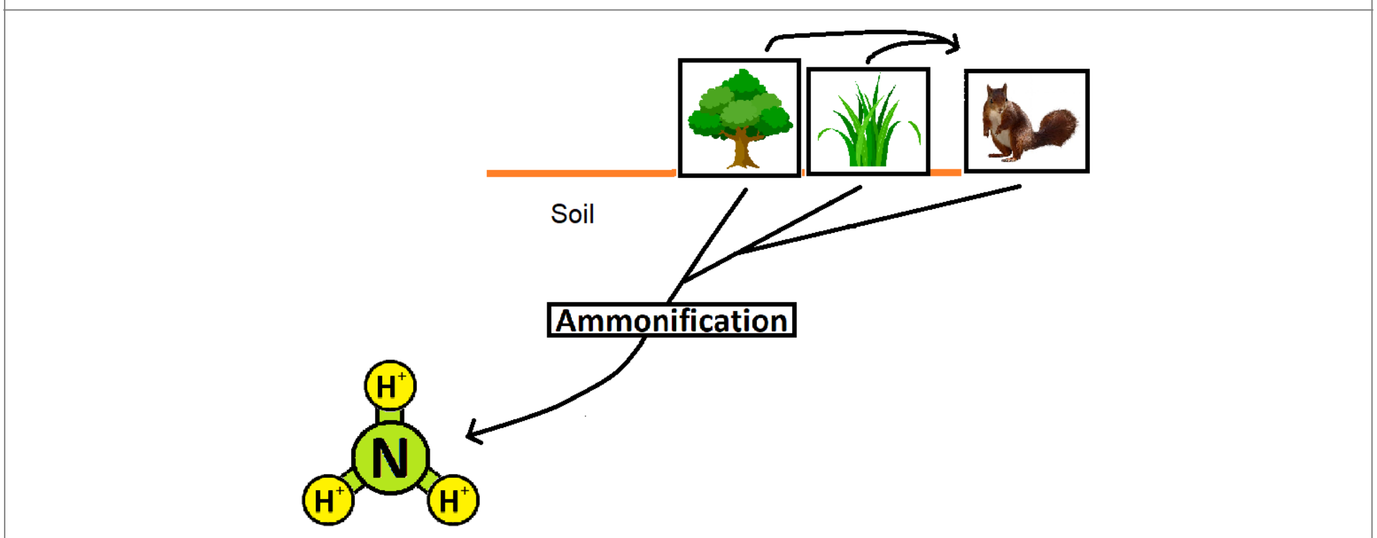


In the **assimilation** step, the nitrate (NO_3) is absorbed by plants and used to make organic molecules such as proteins and nucleic acids. Animals eat the plants to obtain the nitrogen and organic molecules. Use the plant and animal magnets and draw lines to show this step. Note that the plants and animals can be placed above ground level **(figure 12.B.4)**. The **denitrification** process can also be shown here. Draw a line from the nitrate back to the N_2 in the atmosphere. Denitrification is sometimes performed by the Pseudomonas bacteria to obtain oxygen in oxygen depleted soils. Use the Pseudomonas and denitrification magnets along the line drawn for denitrification **(figure 10.B.5)**.

Figure 12.B.4 – Assimilation	**Figure 10.B.5 – Denitrification**
	

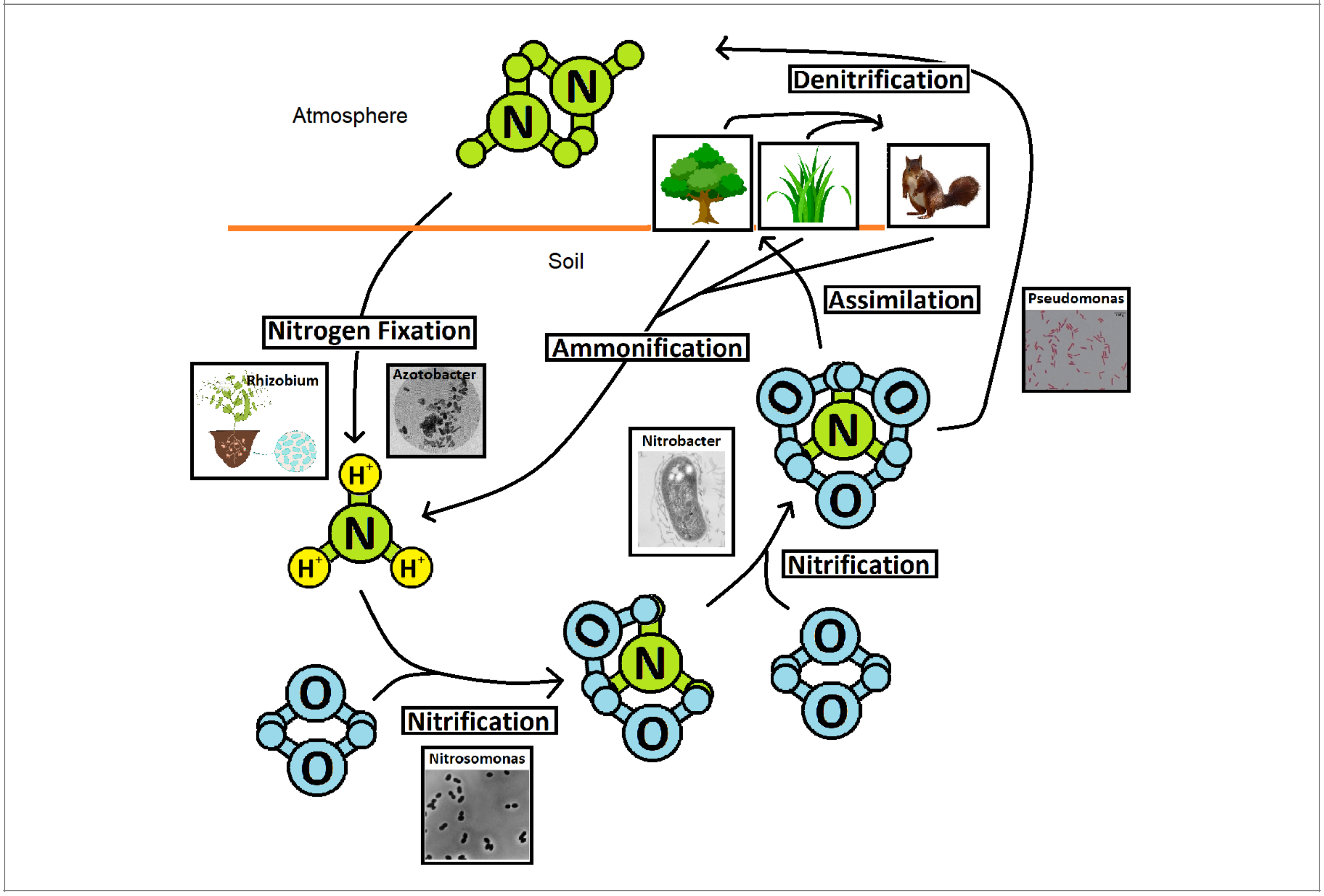
The dead and decaying bodies and wastes of plants and animals are converted back into ammonia (NH3) by a process called **ammonification**. This can be demonstrated by drawing lines connecting the plant and animal magnets back to the ammonia magnets formed in the first step, nitrogen fixation. Use the ammonification magnet to demonstrate this step **(figure 10.B.6)**.

Figure 10.B.6 – Ammonification



The entire process of the nitrogen cycle is shown below **(figure 10.B.7).** Go over the steps again, removing the magnets with the names of the processes and placing them as you describe each step. See if each member of the group can recall the names of each process before placing the process nameplates.

Figure 10.B.7 – The Nitrogen Cycle



Extra exercises:

Details of the nitrogen cycle: The nitrogen cycle is more involved than has been shown thus far. Lightning, fertilizer production, factory emissions and other forms of combustion contribute to the nitrogen in the cycle. Demonstrate these factors using the appropriate magnets supplied with the kit.

Marine nitrogen cycle: Research and discuss how nitrogen cycles in marine (ocean) ecosystems. Make magnets out of index cards and magnetic tape to represent algae, fish, and sediment to show the movement of nitrogen through the marine ecosystem.

Relative amounts of nitrogen: Using the internet for research, find the relative amounts of nitrogen stored in each pool and moving through each process. Which processes are the most important to the nitrogen cycle and would have the largest effect if disrupted? To which processes are humans contributing in the largest amounts?