POGIL 2.3: The Nitrogen Cycle

Review Version

***Read Chapter 2.3 of the E-text and then complete this part of the POGIL worksheet.*

**Please fill out worksheet in a different font or text color (green or blue) so it is easy to distinguish your answer from the questions.

READ THIS: ***Supporting services include primary production because plants and plankton sequester carbon, and thus help regulate climate and the water cycle. Primary production also forms the base of the food chain; it supports pollinators whose numbers regulate plant community composition; plants provide ground cover that regulates erosion; plants support air and water quality through filtration and sediment trapping. In turn, primary productivity in both terrestrial and aquatic systems is controlled by climate, the availability of water, seed dispersal, pollination, available nutrients, and a variety of local conditions.***

Regulating services include:	Supporting services include:
pollination erosion control water purification air quality carbon sequestration climate control	seed dispersal nutrient cycling primary production

Macro and micronutrients that are essential for plant growth	
Primary macronutrients	nitrogen (N) phosphorus (P) potassium (K)
Secondary macronutrients	calcium (Ca) sulphur (S) magnesium (Mg) silicon (Si)
Trace minerals or micronutrients	boron (B) chlorine (Cl) manganese (Mn) iron (Fe) zinc (Zn) copper (Cu) molybdenum(Mo) nickel (Ni) selenium (Se) sodium (Na)

Using information from the screen (table in e-text), answer the following:

EQ1. What are the primary **nutrients** required for plant growth?

Nitrogen (N), Phophorus (P), Potassium (K) (this will be on the exam!)

EQ2. What are the secondary **nutrients** required for plant growth?

Calcium, sulphur, Magnesium, and Silicon

EQ3. What are the trace or **micronutrients** required for plant growth?

Boron, Chlorine, Manganese, Iron, Zinc, Copper, Molybdenum, Nickel, Selenium, Sodium

IQ4. Different plants have different requirements for light, water and nutrients. If any of these requirements are not met, how could the growth of a plant be impacted?

It will reduce plant growth, this is the "law of the minimum"

AQ5. Think back to the composition of the atmosphere (sec 2.1). What is the most abundant molecule found in the atmosphere?

N_2 , this is an inert gas, we can breathe it in and out and it does nothing. It makes up about 78 percent of the composition of the atmosphere.

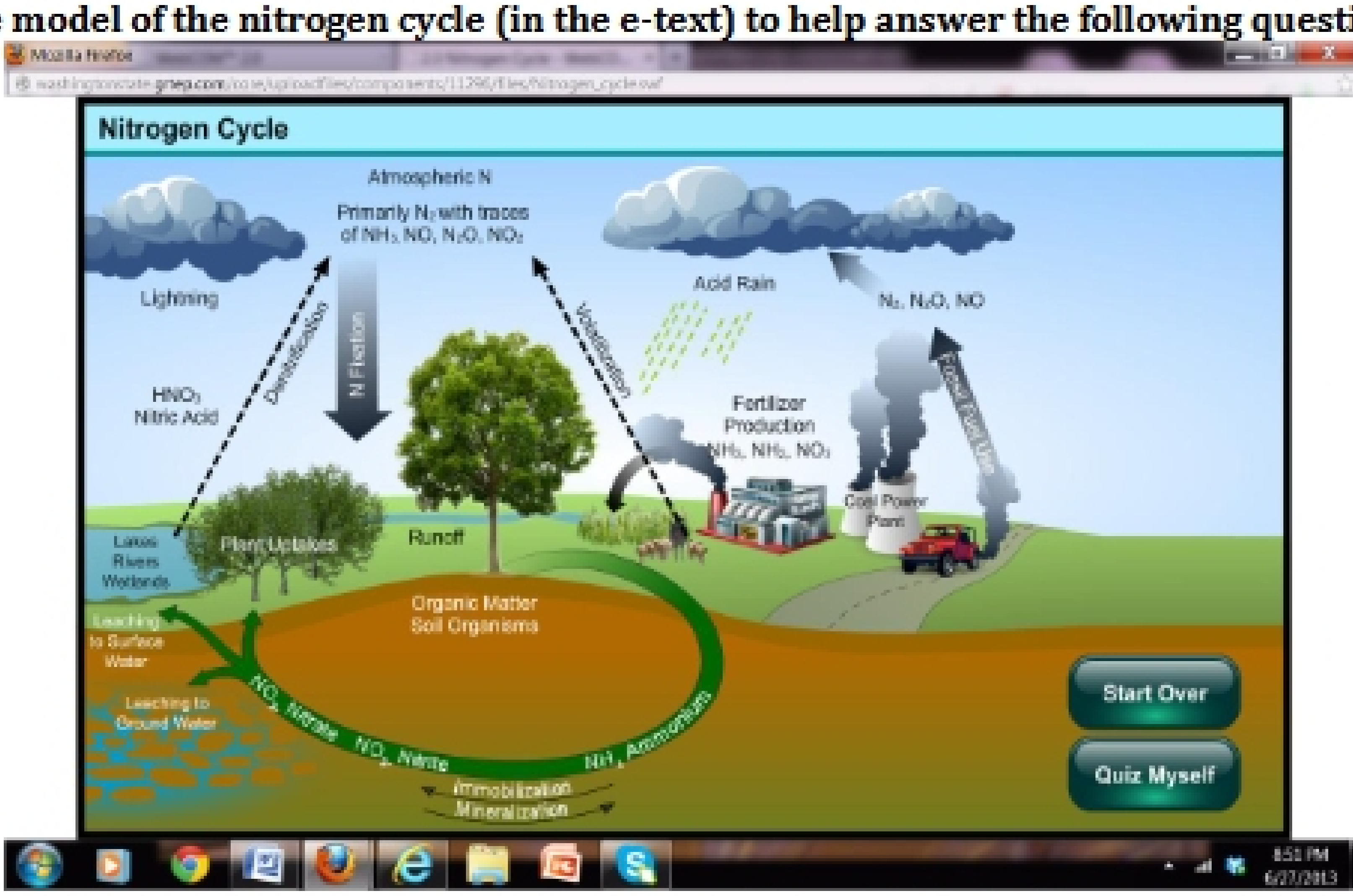
AQ6. Your lungs are full of the molecules from Q5. Do these molecules react with your body other than to fill space in your lungs (thus keeping them inflated)? **No, it is inert.**

READ THIS*: **Nitrogen (**N_2**) is an inert (non-reactive) gas** that comprises about 78% of the atmosphere. Nitrogen from the atmosphere enters into biological systems through a process called nitrogen fixation that converts inert, non-reactive* N_2 *to a reactive form of nitrogen that organisms can utilize for the formation of proteins, DNA and RNA. This type of nitrogen comes in several forms and is called biologically available nitrogen or reactive nitrogen (because organisms can utilize it).***

IQ7. Consider the uses of nitrogen. How would a global increase of biologically available nitrogen influence primary productivity?

It would increase primary productivity, unless there was another limiting factor such as water availability (which we overcome with irrigation!)

Utilize the model of the nitrogen cycle (in the e-text) to help answer the following questions.



EQ8. Lightning fixes nitrogen to become what compound? ______Nitric Acid________

IQ9. Where do you think the oxygen and hydrogen in the compound in Q8 came from?
From water in the atmosphere. The lighting is strong enough to break the N_2 bond which then readily combines with water.

READ THIS*: In natural systems, microorganisms called diazotrophs that include cyanobacteria (blue green algae), Rhizobia and Frankia fix nitrogen using an enzyme called nitrogenase. They convert atmospheric nitrogen (N_2) to ammonia (NH_3). Rhizobia and Frankia form symbiotic associations within the roots of plants. Rhizobia and Frankia provide ammonia (NH_3) for the plant; the plant provides carbohydrates for energy. Plants that form these associations include legumes such as clover, alfalfa, lupine, and beans; and non-legume plants such as alder, buckwheat, and bayberry. Cyanobacteria are free living, prolific and found in soils, bare rock, freshwater systems and the ocean.*

AQ10. Cyanobacteria are free living, or *asymbiotic,* and are able to photosynthesize. Fixing nitrogen requires energy. What do cyanobacteria use as an energy source? (Hint: think back to the carbon cycle… follow the energy!) **the sun! (photosynthesis!)**

IQ11. When plants and animals die, what happens to their bodies?
They decompose

IQ12. The atoms and molecules from dead organisms don't just disappear. What happens to these atoms and molecules after the process described in Q11?
They are incorporated in to the soil; the nitrogen in their bodies can be mineralized

READ THIS*: (very geeky!) When plants, bacteria and animals die, the nitrogen in their tissues is mineralized into ammonium (NH^+_4) through microbial and fungal decomposition. When these bacteria or fungi assimilate ammonium, it is no longer available for plants and is thus immobilized. Certain bacteria convert the ammonium (NH^+_4) into nitrites (NO^-_2) and nitrates ($N0^-_3$) in a process called nitrification. These compounds can be repeatedly cycled in soil systems or can leach into ground or surface water. Terrestrial and aquatic plants can uptake or utilize nitrates ($N0^-_3$) and ammonia (NH_3) as a fertilizer; however, high levels of nitrites (NO^-_2) are toxic to plant life. A similar process of immobilization and mineralization happens in the ocean beginning with nitrogen fixation by cyanobacteria.*

READ THIS*: (the really simple, not too geeky version) When things are decomposed by bacteria and fungi in the soil (or ocean), the carbon parts of organisms (carbohydrates) are used by the bacteria and fungi for energy. Nitrogen is often limited in systems, so bacteria are happy to have a source (protein parts of dead things) and use it for their own proteins, RNA and DNA. When the reactive nitrogen is in the body of a bacterial cell, it is not available to other organisms (so it is immobilized). When the bacteria die, their bodies sort of spill out and release whatever carbohydrates were there and spill out and release reactive nitrogen. The carbohydrates become part of the soil carbon stock (eeek not the carbon cycle again) and the nitrogen gets taken up by plants.*

EQ13. What forms of nitrogen cycle through soils?