Supplemental Material 3. Paired pre-assessment and post-assessment responses for questions requesting written explanations. These examples reflect changes in student reasoning from informal or mixed reasoning to scientific, principle-based reasoning.

Question	Pre-assessment answers	Post-assessment answers	Interpretation of Improvement
1 – Seasonal fluctuation of atmospheric CO_2	"Due to heating/cooling systems (internal heat and ac)." [Informal Reasoning]	"Photosynthesis starts up in the march-april and begins to cut down CO_2. Photosynthesis drops off in Oct-Nov and CO_2 levels rise." [Principle-based Reasoning]	Student connects atmospheric oscillations and biological processes with clear mechanisms.
2 – Cellular respiration as C source in decomposers 3 - Photosynthesis as C sink	"Grandma will be decomposed by organisms, the cresote bush will then soak up the minerals and nutrients from her decomposed body. An animal will come along and eat part of the bush or plant. The coyote will then catch and eat the animal. The carbon from Grandma absorbed by the plant, that was consumed by the animal that was then digested and absorbed into the coyote." [Mixed Reasoning]	"As grandma's body decomposes her carbon is being released back in to the atmosphere as CO_2. The plants that photosynthesize then take in CO_2 from the atmosphere and use it to produce organic compound that compose them. A rabbit will then come along and eat part of the plant and consume the carbon in its organic compounds the carbon that was originally in grandma's body. The rabbit then processes the plants carbon and uses it to produce its own organic compounds. The coyote then eats the rabbit which contain carbon recycled from grandma's body and uses it to make up its bodies tissues." [Principle-based Reasoning]	Student traces carbon from organic material in grandma to carbon dioxide via the process of decomposition, and also traces carbon into the plant from carbon dioxide in the atmosphere.
4 – Cellular respiration and biosynthesis in decomposers	"Whatever the mold consumes, will then be produced as waste, therefore maintaining the original mass." [Mixed Reasoning]	"The mold decomposes the bread and uses it to power processes for life. These process such as cellular respiration release CO_2 back into the atmosphere. Because some of the bread's original carbon is being released into the atmosphere the overall mass will decrease." [Principle-based Reasoning]	Student understands that the mass decreases as the mold converts bread into biomass and gases, and describes how some bread biomass is incorporated into the mold, but some is lost as CO_2 to the atmosphere.
7 – C source for biosynthesis in carnivore	"Plants obtain carbon from the soil and the air to use for photosynthesis. Animals that the coyote eats consume plants. It will be the carbon in the meat from the plants. There could also be minerals and carbon atoms randomly in the air and drinking water." [Mixed Reasoning]	"Plants take in the CO_2 from the atmosphere and then when eaten the C atoms are transferred to the herbivore. So 100% of the herbivores' carbon came from the plant. The coyote eats the herbivore therefore receiving 100% of its carbon from the herbivore, which got its C from 100% plants." [Principle-based Reasoning]	Student identifies that 100% of the carbon originated from plants and herbivores.