

CARBON CYCLE FRAMEWORK
DQC Group – Michigan State University
Duncan Sibley

<i>in or from</i>	Location	Driving force	<i>drives</i>	Process	<i>is</i>	Explanation of process	Help ideas and connections
	Atmosphere to Plants	biosynthesis		photosynthesis		$6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g})$	Plants use energy from sunlight to work against disequilibrium
	Biosphere to Atmosphere	metabolic activity		respiration		$\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \rightleftharpoons 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$	Respiration, performed by plants and animals is the opposite of photosynthesis
	Oceans to Lithosphere	biosynthesis		biochemical precipitation		$\text{Ca}^{2+} + \text{HCO}_3^- \rightleftharpoons \text{CaCO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}$	CaCO_3 is the mineral calcite which makes up limestone
	Atmosphere to Oceans	chemical disequilibrium		gas dissolution		$\text{CO}_2 \text{ gas} + \text{H}_2\text{O} \rightleftharpoons \text{HCO}_3^- + \text{H}^+$	H^+ ions created by this process cause acidification of oceans
	Oceans to Atmosphere	chemical disequilibrium		degassing		$\text{HCO}_3^- + \text{H}^+ \rightleftharpoons \text{CO}_2 \text{ gas} + \text{H}_2\text{O}$	This is the opposite of gas dissolution
	Oceans to Lithosphere	gravity		deposition		Small particulate organic matter deposited	This is mostly in shales. The source of oil and gas
	Lithosphere	heat		maturation		Particulate organic matter converts to coal, oil and natural gas	We mine coal and drill for oil and gas.
	Lithosphere to Atmosphere	chemical disequilibrium / heat and pressure		metamorphic degassing		$\text{CaCO}_3 + \text{SiO}_2 \rightleftharpoons \text{CaSiO}_3 + \text{CO}_2$	Metamorphism of calcium silicates and carbonates returns the carbon lost through weathering.
	Atmosphere to hydrosphere	chemical disequilibrium		weathering		$\text{CaSiO}_3 + \text{H}_2\text{O} + 2\text{CO}_2 \rightleftharpoons \text{Ca}^{2+} + 2\text{HCO}_3^- + \text{SiO}_2$	Weathering of calcium silicates must balance with metamorphic degassing.
	Biosphere to Soil	accumulation		deposition		Dead organic remains	Dead organic matter breaks down
	Soil to Atmosphere	metabolic activity		decomposition		$\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \rightleftharpoons 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$	Bacteria breakdown (respire) organic matter
	Soil to Hydrosphere	gravity		discharge		Soil water carries organic matter to rivers, lakes and groundwater	Includes both dissolved and particulate organic matter.
	Anthrosphere to atmosphere	economic development		burning fossil fuels		$\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \rightleftharpoons 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$	This is the same overall process as respiration. Energy stored in bonds in coal, oil

							and gas is released when they burn.
	Anthrosphere to Hydrosphere and Lithosphere	global warming		Carbon sequestration		CO ₂ injection	This process will be driven by both technology and politics