

## Nine Default Assumptions About the Nature of Causality That Impede Science Learning

<b>Students assume that causality is:</b>	<b>Example</b>	<b>Instead of:</b>	<b>Example</b>
Linear	When I suck on the straw, I make the juice come up.	Nonlinear	There is less air pressure inside the straw than outside, so the imbalance results in the juice getting pushed up the straw.
Direct without intervening steps	Green plants matter to animals that eat them but not to animals that eat the ones that eat green plants.	Indirect	If the green plants disappeared, it would eventually affect everything in the food web.
Unidirectional	Mice matter to owls because they make food for them, but the owls do not matter to mice.	Bi-directional or mutual	The owls maintain balance in the mice population.
Sequential with step-by-step processes	The electrons crowd onto the circuit and go to each bulb so the first one gets the most power.	Simultaneous	The electrons move like a bicycle chain turning in a circle all at once making the bulb light when it moves.
Constructed from obvious, perceptible characteristics	The object sinks because of its weight.	Constructed from non-obvious or imperceptible variables	Density affects sinking and floating.
Due to active or intentional agents	The electrons move to make static electricity.	Due to passive or unintentional ones	Protons and electrons are attracted to each other. Bridges stand because of balanced forces. Seat belts passively cause us to stop when the car stops.
Deterministic--effects always follow "causes" or the causal relationship is questioned	I did it before and I didn't get sick, so I'm not going to get sick now.	Probabilistic	Getting sick depends upon many things. Even if I didn't get sick before, I can still get sick now.
Spatially and temporally close to its effects	I can't see any bad effects of getting a suntan right now.	Distant or having delays	The hurtful effects of getting a suntan accumulate and show up after along delay between cause and effect.
Centralized with few agents	The queen bee directs the activity in a beehive.	Decentralized with distributed agency and emergent effects	The interactions of many bees result in an organized system.