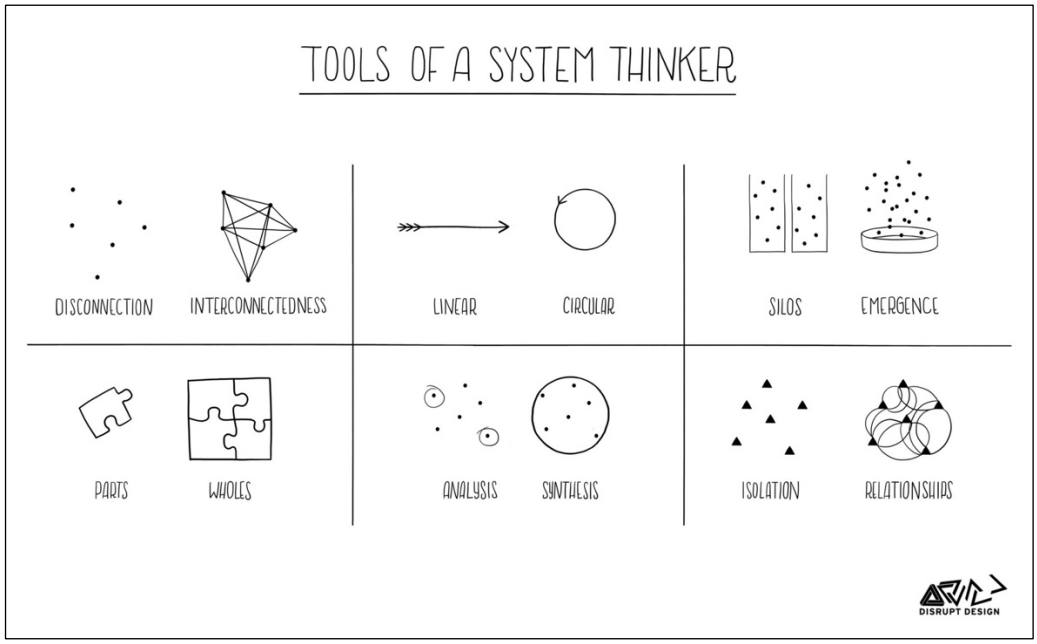
Systems Thinking

- A "Very, Very Simple Climate Model" lets you explore how CO_2 and temperature levels still continue to rise even if emissions of CO_2 flatten out, or even begin to drop (~10:00) https://scied.ucar.edu/simple-climate-model

What is systems thinking? It is a way of thinking about the world around us as – systems. It means naming the parts (or "components" in a system, and exploring how they are connected. It means exploring how these connections produce the behavior of the system. It means thinking about interconnected relationships, about how parts connect as wholes, about how behavior can arise from the connections among parts, called "emergence."



Credit: Emma Segal

Think of the major components of the global climate system. Earth's climate is shaped by land (soil, rocks), water (clouds, water vapor and ice), air, and life. All these components are interconnected. Changes in any one of them affects the others as well.

There are a few key systems thinking concepts you need to understand.

Feedback loops circle from one component back to the original component. The feedback can either **reinforce** an effect (make it stronger) or **balance** an effect (dampen it). Every part of the climate system is involved in one or more feedback loops. (See Feedbacks section for more information.)

Systems have **time delays**. A system component can take time to "react" to a change in another part of the system. For example, the ocean is absorbing a lot of the heat being trapped in the Earth system by greenhouse gases. This heat doesn't disappear. It re-enters the rest of the Earth system by melting sea ice, by evaporating water, or directly reheating the air above. Because of this, heat energy in the ocean can warm the planet for decades after it was absorbed.

Any big change in one component of the Earth system can change the equilibrium of the whole system. For example, the small difference between frozen water and melting water can make permafrost in the far north reach a **tipping point.** It quickly flips from being frozen to thawing, and this will release lots of carbon from the previously frozen soil. In a reinforcing feedback, this will quickly result in more rapid warming.

More information

- This 4-min video explains reinforcing and balancing feedback loops in the Arctic, and explains why weather extremes are likely to happen
  http://ed.ted.com/lessons/why-the-arctic-is-climate-change-s-canary-in-the-coal-mine-william-chapman
- The Amazon forest ecosystem is a good example of a complex system that is currently changing because of feedbacks. (See if you can answer the discussion questions on the web page.)
  http://serc.carleton.edu/eslabs/carbon/2c.html