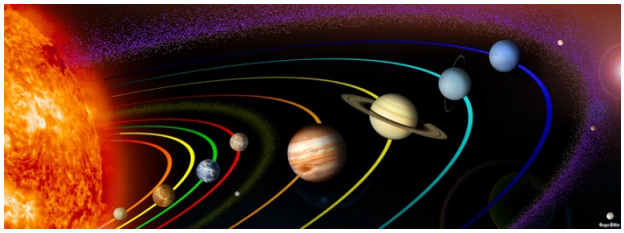
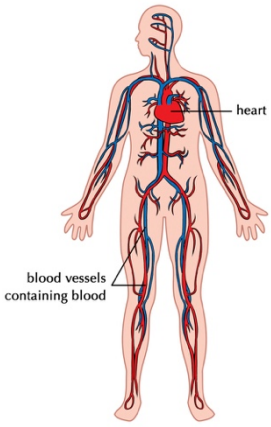
Systems and Systems Thinking

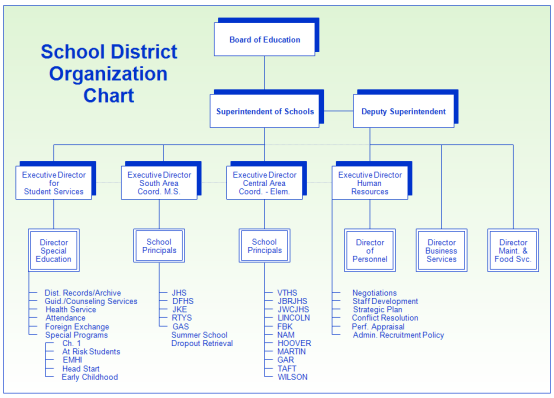
What do we mean by a *system*? Here are some examples:



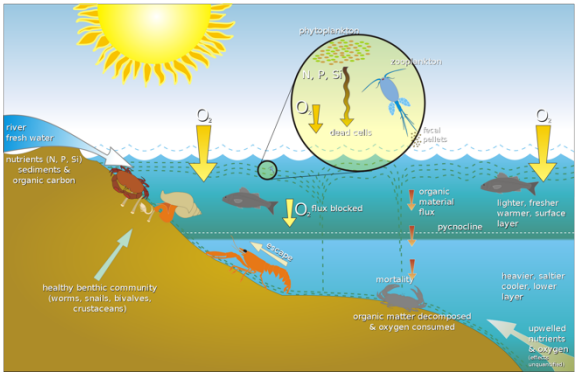
Solar System



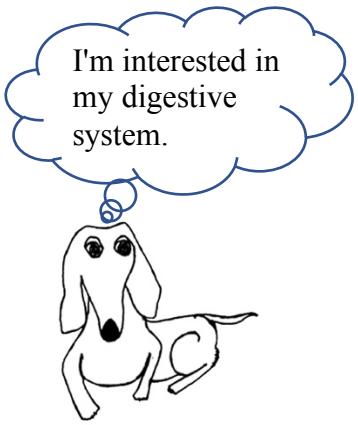
Circulatory System



School System



Freshwater ecosystem



A system and its components
What do these systems have in common? Each one is comprised of a set of components – planets, blood vessels, people, plants and animals – that interact with and affect one another. What happens to one component can't be well understood, explained, or predicted without taking the others into account. That kind of analysis is what we mean by *systems thinking*.

Deciding where to put the boundaries
A second common feature is that defining a system means drawing a boundary between what's inside and what's outside the system. For example, the solar system boundary can be thought of as an imaginary container in space. In the case of the circulatory system, it's just a conceptual boundary – all the tissues

in the body participate in circulation, but when we think about the circulatory system we include only the tissues that participate in blood flow and ignore all their other important characteristics.

Deciding where to put that boundary is a crucial step in systems thinking, and there's no definite rule – it depends on the phenomenon you're looking at and the questions you're interested in asking, and there may be more than one valid choice. Often you'll decide to leave things outside the system if their effects are small, *or* you can just include those effects as relatively simple inputs, outputs, and constraints.

Take the solar system as an example. If you just want to understand why there are seasons, it's enough that the system include the Earth and the Sun. If you want to understand eclipses, you'd better include the Moon, too. And if you want to send a spacecraft to Mars, you'd better include Mars, and probably Jupiter and the inner planets.

Systems in an energy context

How do these ideas play out in the context of energy? Consider the case of two balls colliding on a track. Clearly the balls are in the system, but what about the track? The person who set the balls in motion? The air in the room? If all you're interested in is what happens in the collision, all you really need in the system are the balls – the track is just a constraint, keeping the balls moving in a line, and the person just provided the initial input of energy. But if you want to take a broader look at where the energy came from and where it goes, you might want to include the person, track and air as components that can gain and lose energy. There's no "right" choice.

Systems thinking and models

Systems thinking is one aspect of the practice of creating and using models. By choosing what to include in the system, how to incorporate any effects from the world outside the system, and how to think about the interactions that happen inside the system, we're creating a conceptual model of the real situation. Like all models, the system will be simplified and more useful for asking and answering some questions than others.