

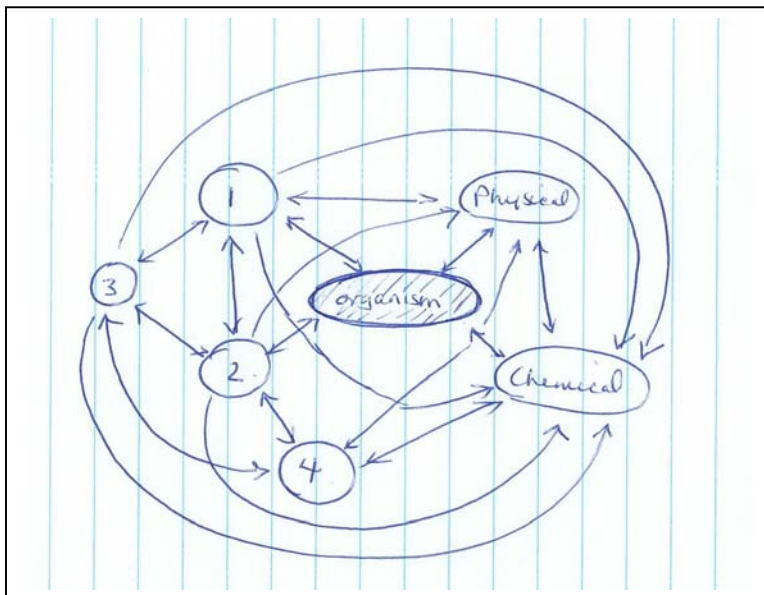
## Systems Thinking

“Systems thinking looks at the whole, and the parts, and the connections between the parts, studying the whole in order to understand the parts. It is the opposite of reductionism, the idea that something is simply the sum of its parts. A collection of parts that do not connect is not a system. It is a heap” (O’Connor and McDermott 1997). A system, then, is a set of **interrelated** parts that make up the whole. Some good examples include the human body, an ecosystem, a society, and the global economy.

Scientists and engineers have traditionally reduced the whole into small parts in both studying the world and developing solutions to problems. Often they have not considered the interconnections of the parts. Scientific reductionist thinking is currently one of the predominant paradigms in the world and has led to simple cause and effect thinking and a linear mechanistic view of the world. We know that the world and current world problems and concerns are not simple. They are all complex, dynamic and nonlinear and thus require a systems approach for finding solutions.

### Don’t believe everything you think!

Paradigm is the word coined by Thomas Kuhn in 1962. It is a word used to describe a belief system, but it means much more. A paradigm is the **commitment** to a belief system. This commitment means that even when we are faced with evidence that contradicts that belief (e.g. when things don’t fit the belief), we either “make them fit”, or ignore them. This happens in science, engineering, politics and even our social systems. Societal paradigms, for example, shape our language, thought, even our perceptions. A paradigm is so intrinsic to the way we think that we aren’t even conscious of its existence until we try to communicate with someone with a different paradigm, or we start noticing enough things that ‘don’t fit’ the paradigm.



The interrelationship of the system components is often best viewed as a **web**. The figure to the left is a relatively simple example showing an organism interacting with other organisms (represented by the circles 1, 2 for direct interaction, and 3, 4 through indirect interactions) and the physical and chemical aspects of its environment. Interactions between organisms would include both competition and cooperation.

In a system the following concepts apply:

1. Everything is connected to everything else, even if it is not a direct connection.
2. The internal structure is important for the stability of the system.
3. Rarely does one cause (or perturbation) lead to one effect, or vice versa, does a given effect have only one cause. Because of the complexity and interconnectedness of the parts, some impact on a part could have multiple effects, or one effect might be the result of several different perturbations to the system.
4. Systems are dynamic (constantly changing).
5. Systems vary both spatially and temporally.
6. Systems are not generally described by linear relationships.
7. There are often threshold responses in a system (e.g. small perturbations do nothing, but bigger ones causes dramatic effects).
8. Both positive and negative feedback are possible.

**A systems approach to engineering problem solving** would take on this holistic view of both the problem and its possible solutions, and consider the potential interactions and feedback among the components in a problem/solution. Additionally, a systems approach considers the broader impacts of both the problem and solutions, including the environmental, economic, social, and political considerations. At the University of Vermont, we are training civil and environmental engineers to take a *SYSTEMS APPROACH* to solving problems. This is a broad based approach that uses holistic thinking when looking at engineering systems and attempts to consider and minimize the negative impacts to the environment and society in the solution.

## References

Kuhn, T. *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago. 1962.

O'Connor, J. and McDermott, I. *The Art of Systems Thinking*. Thorsons, England. 1997.

Systems Thinking: An Operational Perspective of the Universe. Website. <http://www.systems-thinking.org/systhink/systhink.htm> 2004.

Oregon State University cross-disciplinary course in Systems Thinking. Website: <http://oregonstate.edu/instruct/stp/> 2004.