What is Panarchy?
An MSE Product: www.ithaca.edu/mse

In thinking about the relationship of parts of a system to each other, and the structure of the overall system, one structure that most people are familiar with is a hierarchical one. A good example is the system of governance in the U.S. At the top of the hierarchy is the federal government; below that are the state governments; next down are county governments; then come town or townships; and finally individual cities and villages. Many systems are organized into top-down hierarchical systems like this: corporations, school districts, even our weather (global circulations down to localized microclimatic events). In these sorts of systems most or all of the control and information flow is from the top to the bottom with very little flow in the reverse direction.

There are other hierarchical systems that are organized from the bottom up. For example, river systems start with many little rivulets that flow into primary streams that flow into secondary streams that merge into small rivers that result in large rivers. Other examples include bioaccumulation of toxins in food webs, where an extremely diffuse pollutant is taken up in low quantities by species low on the food web (e.g. phytoplankton, plants), becomes more concentrated at the next level (e.g. herbivorous fish and insects), and finally becomes toxic to organisms at the top of the food web (humans, swordfish, eagles, polar bears, etc.)

Integrated ecological systems and the types of systems that we deal with when working with the big problems of the 21st century have a kind of hierarchy in that there are small scales imbedded within in larger scales; ecologists call these "scales of integration". For example, individual organisms typically exist in same-species (populations), that in turn form structured systems with other species (biotic communities), that interact with the local, abiotic environment (ecosystems), that cluster into systems with large-scale similarity (biomes), that exist on this earth (biosphere). Many of these systems are hierarchical in that there are levels nested within levels, but they are different from the hierarchical systems we are familiar with because information and control flows both directions. For example, plants (a low level of integration) take up CO_2 and produce O_2. Thus, plants, operating up through all the levels ultimately control the atmospheric composition of the earth. However, the atmospheric composition of the earth plus the energy from the sun controls earth's temperature. Furthermore, total atmospheric CO_2 concentration is also affected by chemical exchange with the oceans, and in turn affects rates of photosynthesis. In this example, no level in the hierarchy is ultimate control point; the flow of information and control goes all directions.

To make things more interesting, in the sorts of systems we are dealing with today, each level undergoes changes through time. Thus we have a system with nested components, information flowing all directions, and each component changing in time governed by processes operating at that particular level.

Panarchy is one term used to describe such a structure. Coined by Lance Gunderson and C. S. Holling the term "panarchy" refers to the Greek god of nature Pan. It is intended to imply the antithesis of the word "hierarchy", which literally means "ranked division of angels" or "high priest, leader of sacred rites". A hierarchy, in other words, is an ultimately *ordered* relationship. The term panarchy, on the other hand, is meant to conjure visions to the wonderful and incredible complexity of natural systems that, sometimes seemingly miraculously, keep us alive.

Natural systems and human-ecological systems are often structured into panarchies. Human activities at all levels, from individual behavior, through local and regional group behavior, and up to national and international interactions are driving changes in atmospheric composition that are resulting in global climate change. Each household, region, country has different standards of living, and different levels of wealth, technology and governance that effect the behavior of the parts of the system. In turn, global climate change is affecting weather

patterns, food production, water availability, interactions among all other plants and animals. The effects of these interactions, come back to effect people.