a complex system is ...
... a set of interconnected parts
making an integrated whole ...
... that exhibits behavior not obvious from the properties of the parts
complex or not?
can we *predict* the behavior?
complex or not?
can we *predict* the behavior?
some characteristics of complex systems ...
boundaries may be indeterminant

usually are open

may have memory
generally are dynamic relationships are nonlinear
Complex systems often show ... 

... self-organization and emergent behavior
self-organization is ...
... the spontaneous formation of structures in systems composed of few or many components.
emergence is ...
... the arising of novel and **coherent** structures, patterns and properties during the process of self-organization in complex systems
why and how?
cellular automata
Emergent behavior: THE GAME OF LIFE

create a square lattice of sites:

each site can be occupied ("alive") or empty ("dead")

create rules for creation and destruction of "lifeforms"

at each step, apply rules and advance system

look for emergent behavior

JOHN CONWAY
<table>
<thead>
<tr>
<th>t</th>
<th>t+Δt</th>
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<tbody>
<tr>
<td></td>
<td>if exactly three neighbors:</td>
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<tr>
<td></td>
<td>dead ⇒ alive (&quot;birth&quot;)</td>
</tr>
<tr>
<td></td>
<td>if 2 or 3 neighbors: stay alive</td>
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<tr>
<td></td>
<td>(&quot;survival&quot;)</td>
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<tr>
<td></td>
<td>if too many or too few neighbors:</td>
</tr>
<tr>
<td></td>
<td>alive ⇒ dead (overcrowding or loneliness)</td>
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</tbody>
</table>
THIS IS A “GLIDER”
The game of life shows organized behavior that “mimics” complex biological systems. The organized behavior **emerges** from the interaction of “parts” by specific, very simple rules.
Wolves and Moose
agent based modeling

multi agent systems
see MAS_Anasazi.pdf on WebCT
complexity in society
complex adaptive systems

complex systems that have the capacity to evolve and adapt
is society a complex adaptive system?
of course

society can change and adapt to new circumstances
some attributes of the societal system that we might want ...
Resilience

– the capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity, and feedbacks
Adaptability

– the capacity of actors in a system to manage resilience, either by moving the system toward or away from a threshold that would fundamentally alter the properties of the system.
Adaption

– the process by which an organism becomes better suited to its habitat
a fundamental property of a system is that optimization of a system ≠ optimization of the individual parts
how do we optimize a system?
complex system optimization

an ongoing area of research

generally done with a simulation of a model
problem: we have an incomplete description of the system
a local approach:

optimize a technology by including the effects of everything else as a constraint
appropriate technology

technology that is appropriate to the social, economic, and environmental state of a given situation
appropriate technology

not just for the developing world, though it is most often discussed in that context
• Societies are complex adaptive systems (a metaphor)

• A complex system is a set of interconnected parts making an integrated whole whose behavior cannot be predicted

• A complex adaptive system is a complex system that evolves with time

• Optimizing a technology within the context of society requires consideration of social, economic, and environmental constraints

Summary
Thought for the day:

from the BBC:
“Engineering Earth is ‘Feasible’”

http://news.bbc.co.uk/2/hi/science/nature/8231387.stm

Given what we discussed today, what is your reaction to this idea?
Questions ???