

Self-Organization of Complex Systems
Chaos, Fractals, Self-Organization and Emergence
John Boccio, Emeritus Professor of Physics
Swarthmore College

Syllabus

Fall 2018

First Thoughts

Chaos

- Big Picture
- Difference Equations
- Approach to Chaos
- Dynamic systems and chaos
- Logistic map
- Time series and Phase space
- Attractors, fixed points, basins and limit points/cycles
- Period Doubling
- Return maps
- Lyapunov exponents
- Bifurcation diagrams
- Sensitivity to initial conditions
- Onset of chaos
- A real physical system - The damped-driven oscillator
- Phase Space
- Poincare plots
- Strange attractors
- Self-similarity
- Basins and attractors

Fractals

- Big Picture
- Fractal dimension
- Cantor Set
- Devil's Staircase
- IFS Fractal Generation
- L-System Fractal Generation
- Fractal dimension Program
- Complex maps - Mandelbrot set
- Roots of Three
- Fractal Examples in Nature
- First thoughts about complexity

Self-Organized Criticality, Complexity and Emergence

First Thoughts

Emergence versus Reductionism

Complexity and Physics

Big Picture

Complexity and Criticality

Self-Organized Criticality

Story Telling(Narrative) versus Science

What Can a Theory of Complexity Explain?

Catastrophes Follow a Simple Pattern

Connection with Fractals

Equilibrium versus Complexity

Chaos is not Complexity

The Discovery of Self-Organized Criticality

Simple Models and Spherical Cows

Computer modeling and simulation

Sand Piles and Rice Piles

Experiments with real systems

Flocking

The crust of the earth

Landscapes and Earthquakes

Life, Evolution and Punctuated Equilibrium

The Game of Life

Interacting Dancing Fitness Landscapes

Can We Model Darwin?

Dante Chialvo's Evolutionary Game

Mass Extinctions

Did an asteroid kill the dinosaurs?

Self-Organized Criticality and Gaia

Replaying the Tape of Evolution

Some Possible Theories

Complexity and Information

Forest Fires and SOC

Percolation

Critical Points

Summarizing SOC

The Brain

Economics

Traffic Jams

Self-Organization in Biological Systems