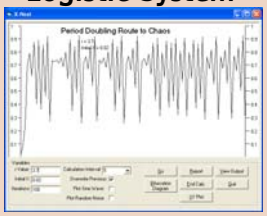
Chaos/Complex Systems Theory Learning Progression

Chaos Theory

Logistic System

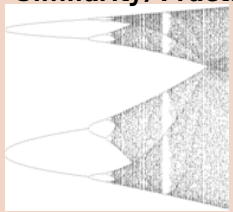


1. Computational Viewpoint
2. Positive/Negative Feedback
3. 'r' Values
4. Deterministic is not Predictable

Bifurcation Diagram

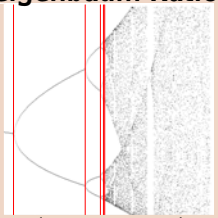
5. Bifurcation = change in behavior
6. Instability increases with 'r'.

Self-Similarity/Fractals



7. Self Similarity
8. No typical/average size of events/objects
9. Non-whole number dimensions

Feigenbaum Ratios

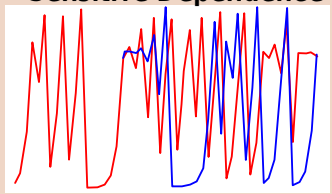


10. All complex systems accelerate rate of chage at the same rate.

Increasing Instability

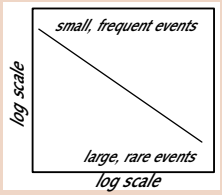
11. All changes (bifurcations) preceeded by increasing instability

Sensitive Dependence



12. Miniscule changes in 'r' can result in dramatic changes in behavior.

Power Laws



13. Small - low energy - events very common; large - high energy - events very rare.

Strange Attractors

14. Behaviors have recognizable large scale patterns but never repeat the same path.

Complex Systems Theory

A group of "agents" (individual interacting units, like birds in a flock, sand grains in a ripple, or individual units of friction along a fault zone), existing far from equilibrium, interacting through positive and negative feedbacks, forming interdependent, dynamic, evolutionary networks . . . . . leading to increasing complexity, diversity, order, and/or interconnectedness

Fractionating Evolutionary Mechanisms

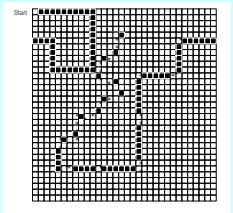
Self-Organizing Mechanisms

Elaborating Evolutionary Mechanisms

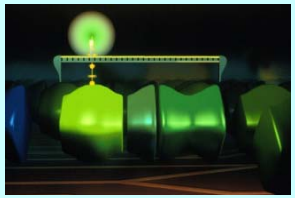
Word Evolv

15. The general evolutionary algorithm—1) differentiate, 2) select, 3) amplify, 4) repeat—is an extremely efficient and effective method of natural selection.

John Muir Trail



Tierra/Avida

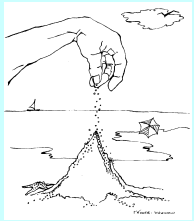


Ancestral Program - consists of three 'genes'

Boids

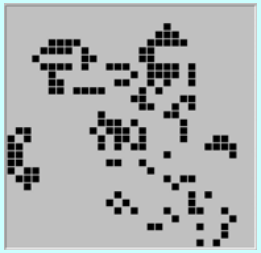
16. Local Rules lead to Global Behavior, self organization arises spontaneously without design, or purpose, or teleological mechanisms.

Self-Organized Criticality



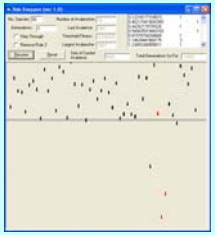
17. All open systems dissipating sufficient energy evolve—self-organize—to critical, sensitive dependent states which lead to avalanches of change that follow a power law distribution.

Cellular Automata



18. In a complex system everything is connected with everything else. Nothing exists in isolation from the rest, sitting in a protected niche, independent and self-sufficient.

Bak-Sneppen



19. In a complex system no one can be completely safe, with complete control over their fate.

Fichter, Pyle, Whitmeyer, (in press), Strategies and Rubrics for Teaching Chaos and Complex Systems Theories