Central question for the sciences of complexity
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— limited communication among components
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give rise to complex (“adaptive”, “living”, “intelligent”) behavior, involving
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— information processing and computation
— complex dynamics
— evolution and learning?
Core disciplines of the science of complexity

**Dynamics:** The study of continually changing structure and behavior of systems

**Information:** The study of representation, symbols, and communication

**Computation:** The study of how systems process information and act on the results

**Evolution:** The study of how systems adapt to constantly changing environments
What We’ve Covered
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• Netlogo

• Dynamics:
  – Linear vs. nonlinear behavior
  – Logistic map, fixed point vs. periodic vs. chaotic attractors
  – “Random” complex behavior from simple deterministic rules
  – Period doubling route to chaos
  – Feigenbaum’s constant
• **Information:**
  – Energy, work, entropy
  – 2nd law of thermodynamics
  – Maxwell’s demon
  – Statistical mechanics / Boltzmann entropy
  – Microstates and macrostates
  – Shannon information content

• **Computation:**
  – Gödel’s theorem
  – Entscheidungs problem
  – Turing machines
  – Uncomputability of the Halting Problem
• **Evolution:**
  – Darwinism
  – Mendelism
  – Modern Synthesis
  – Challenges to Modern Synthesis

• **Defining and measuring complexity**
  – Algorithmic information content
  – Logical depth
  – Thermodynamic depth
  – Fractals and fractal dimension
  – L-systems

• **The evolution of altruism** (Jeff Fletcher)
• **Genetic algorithms**
  – Robby the robot

• **Cellular automata**
  – Game of Life
  – Wolfram’s classes
  – Langton’s lambda parameter
  – Evolving cellular automata with genetic algorithms
  – “Particle-based computation” in cellular automata

• **Random Boolean networks** (Christof Teuscher)

• **Information Processing in Living Systems**
  – Ant colonies
  – Immune system
  – Bacteria
• **Modeling**
  – Prisoner’s dilemma
  – Modeling social norms and metanorms
  – Spatial prisoner’s dilemma

• **Networks**
  – Network structure: path length, clustering, degree distribution, etc.
  – Small-world networks
  – Scale-free networks

• **Scaling**
  – Metabolic scaling
  – Scaling in cities
  – Zipf’s law
  – Benford’s law

• **Analogy-making**
  – Copycat
Goals of the Science of Complexity
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• Cross-disciplinary insights into complex systems
Goals of the Science of Complexity

- Cross-disciplinary insights into complex systems
- General theory?
Goals of the Science of Complexity

- Cross-disciplinary insights into complex systems
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Goals of the Science of Complexity

- Cross-disciplinary insights into complex systems ✔
- General theory? ☑