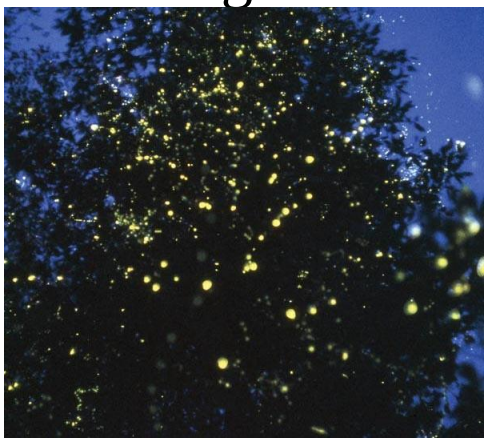
Scientific Investigation

To discover the rules behind a given phenomenon

- Observe and analyze relevant data
- Develop hypotheses (your own guessed rules)
- Test hypotheses through more experiments, analysis, simulation
- Compare the results from the tests to the observed phenomenon
  - If they are consistent, great
  - If not, go back to make more observations, revise hypotheses, do more tests … until discovering rules or concluding the problem to be very hard…

Emergence

- global, unexpected patterns emerged out of local, simple interactions
  - e.g the synchronization of hundreds or thousands of fireflies: First they flash randomly but after some time and influencing each other, they flash in sync.
    - No leader control
    - Simple rules behind this: all fireflies have nearly the same frequency for their flashing, but their phase is shifted. If a firefly receives a flash of a neighbor firefly, it flashes slightly earlier.



Emergence Examples (http://en.wikipedia.org/wiki/Emergence)

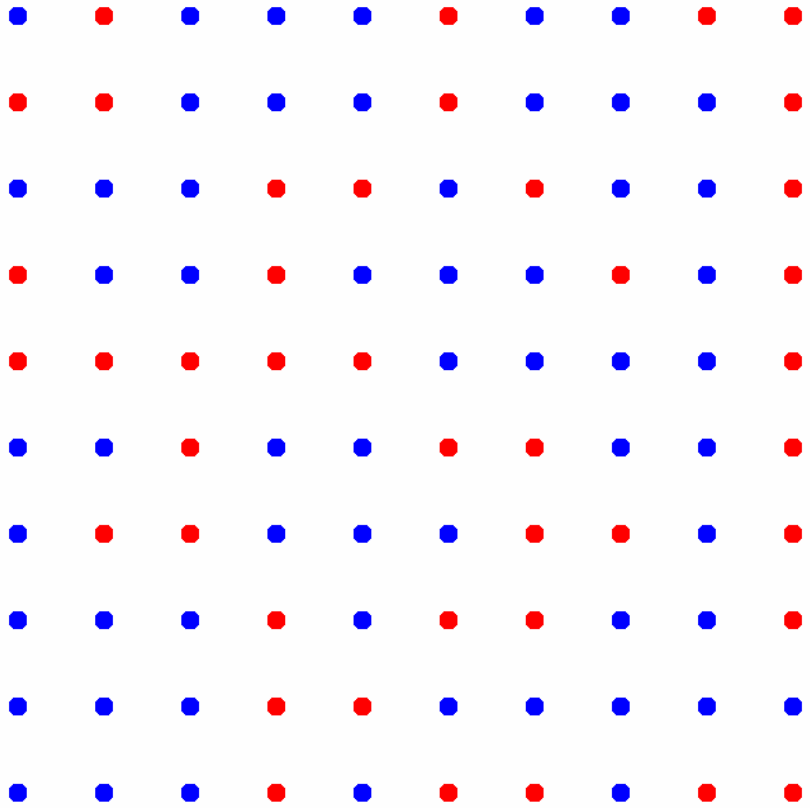
- Emergence in Nature
  - living, biological systems:
    - a school of fish, a flock of bird: Rules -- go in the same direction as neighbors, don't get too close, and flee any predators
  - Non-living, physical systems

- Emergence in humanity
  - economics, internet, cities
- Emergence in political philosophy

…

Our Emergence Example

- 2D array of dots, initially with a random distribution of red and blue colors, e.g.



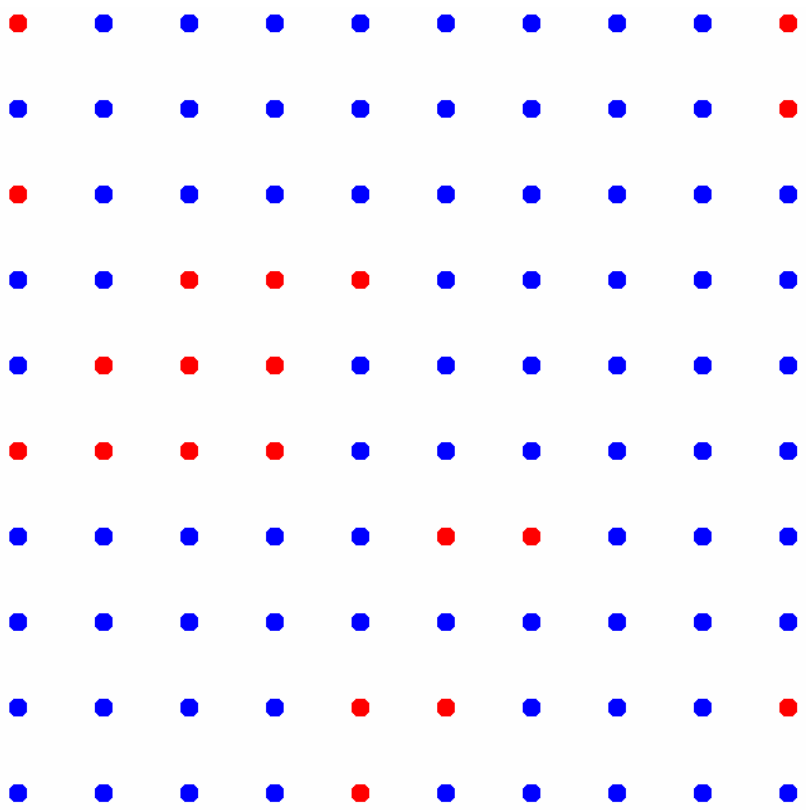
Initial setup

Our Emergence Example (cont.)

- At each step
  - Each dot checks its neighbors' colors and determines what'll be its own color
- Challenge: we don't tell you the color update rules
  - What are a dot's neighbors?
  - How does a dot decide its own color at the next step based on its neighbors' current colors?
- You need to use the scientific investigation process to try to discover the rules
  - First, observe some example data
  - Develop your hypotheses
  - Test your hypotheses through programming
  - Refine your hypotheses if needed

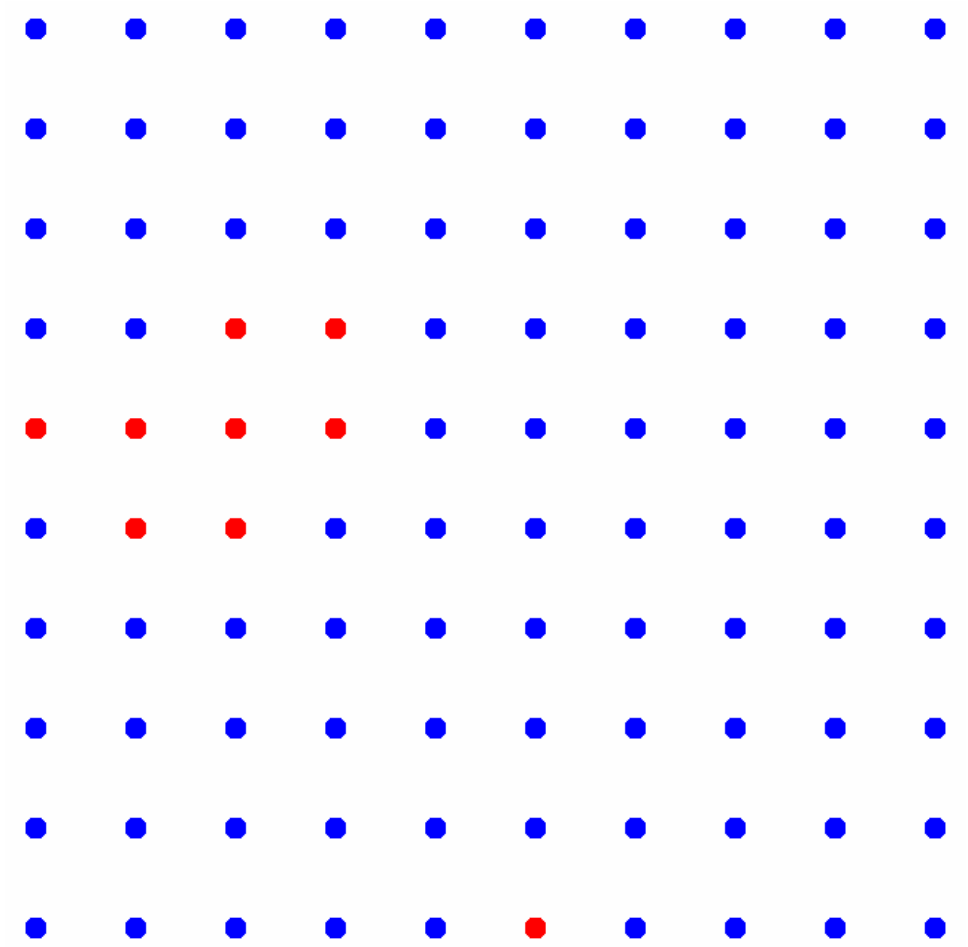
Our Emergence Example (cont.)

The dot colors at subsequent steps, for the initial setup given 2 slides earlier:



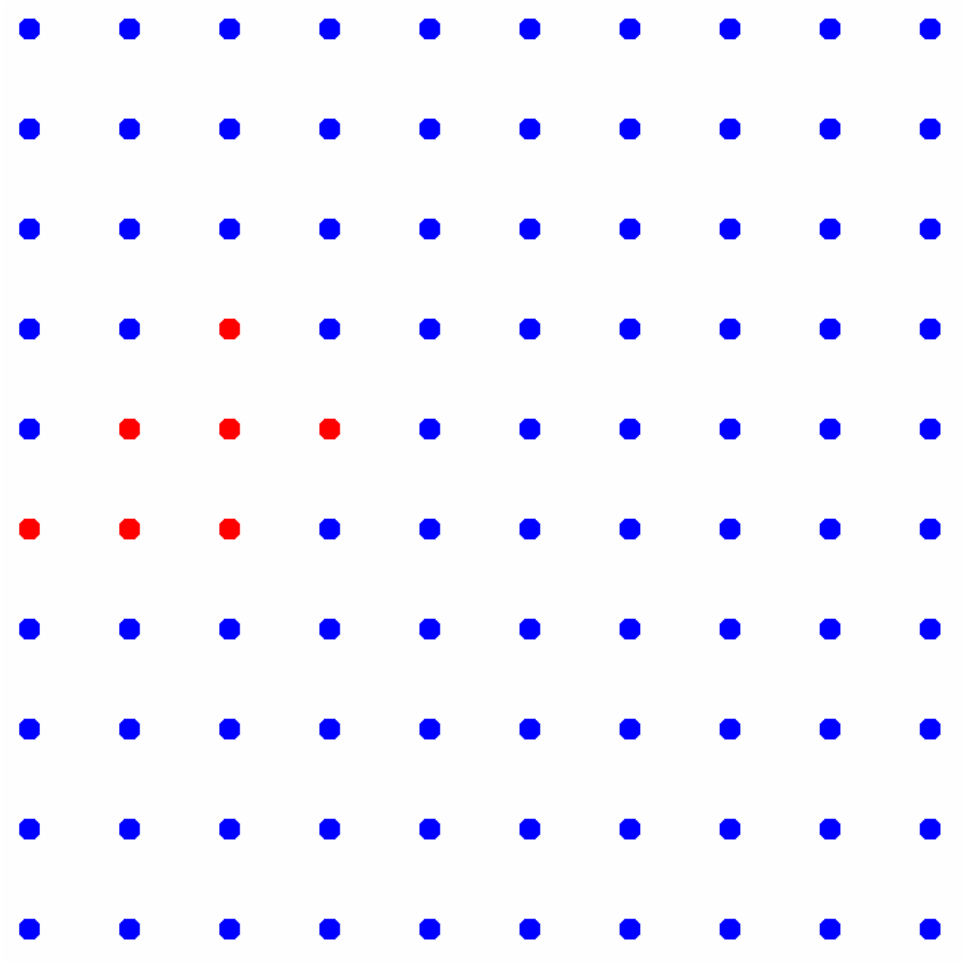
Step 1

Our Emergence Example (cont.)



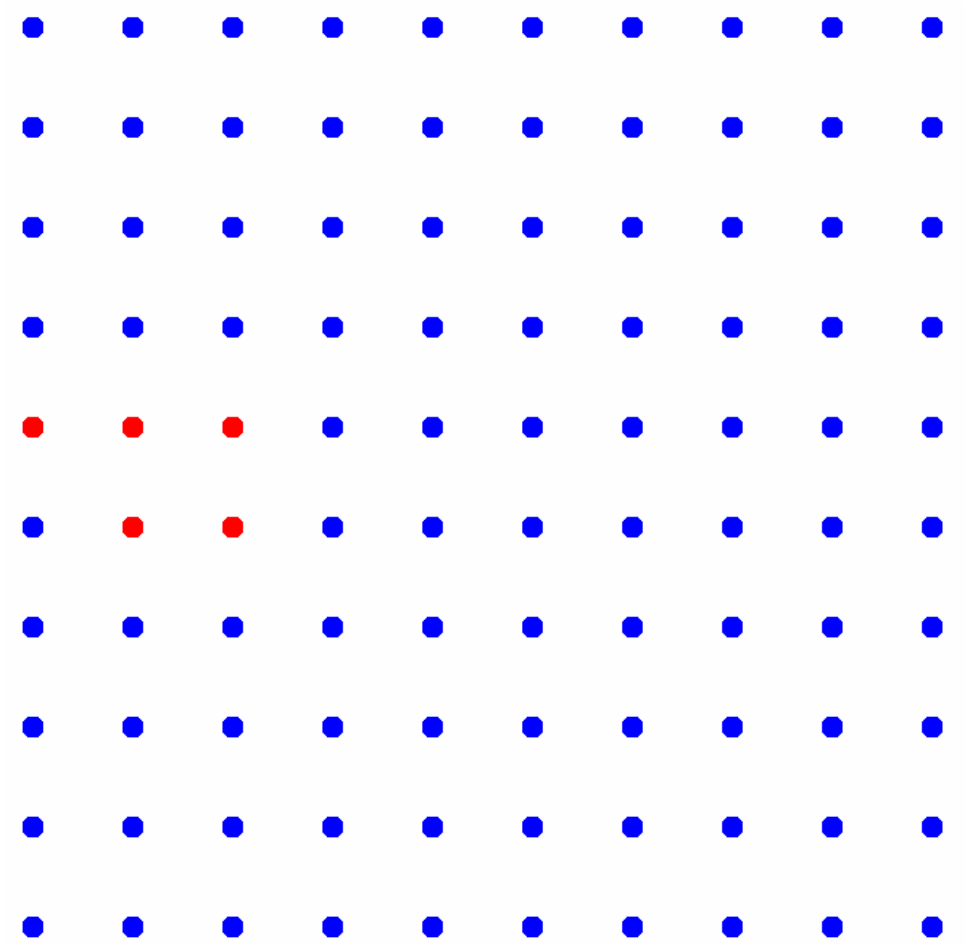
Step 2

Our Emergence Example (cont.)



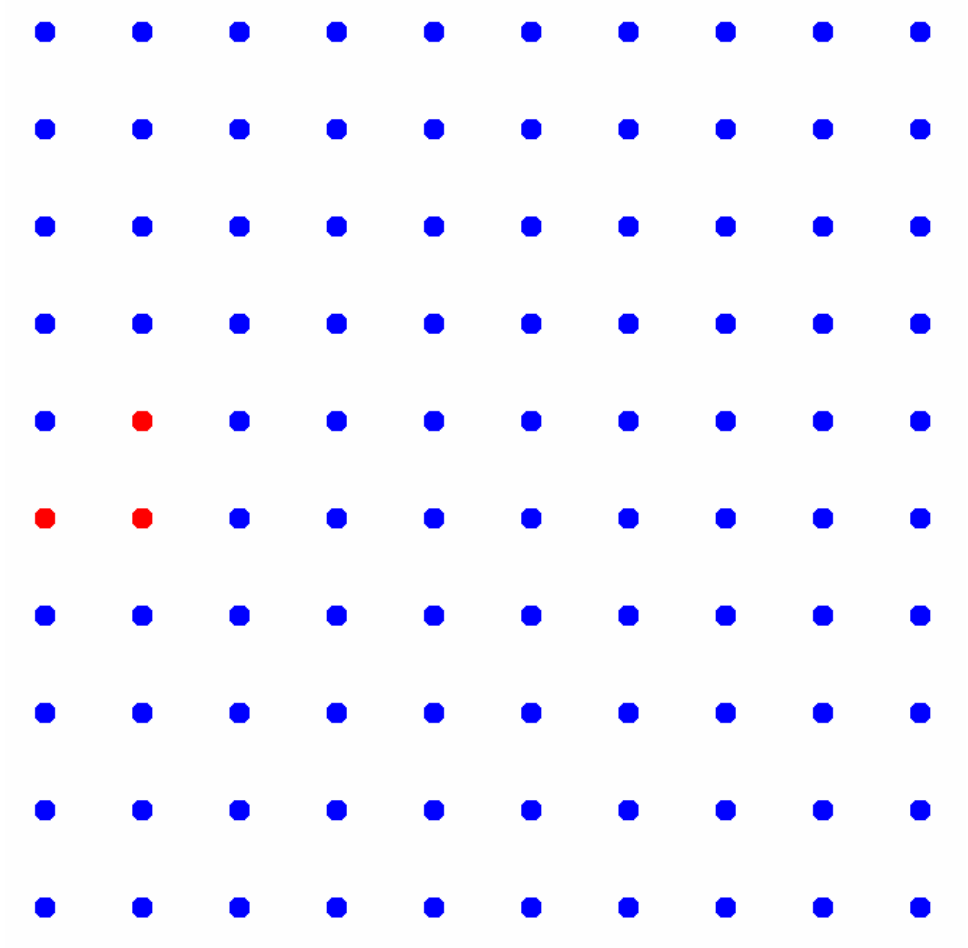
Step 3

Our Emergence Example (cont.)



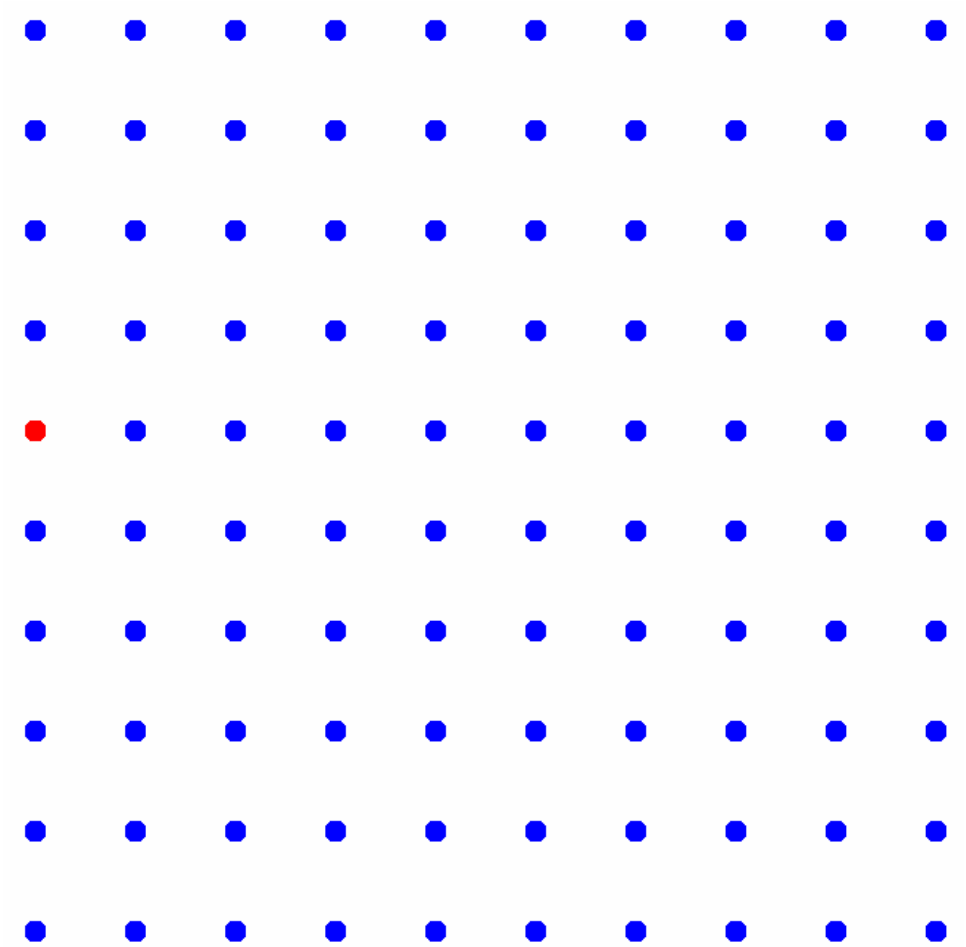
Step 4

Our Emergence Example (cont.)



Step 5

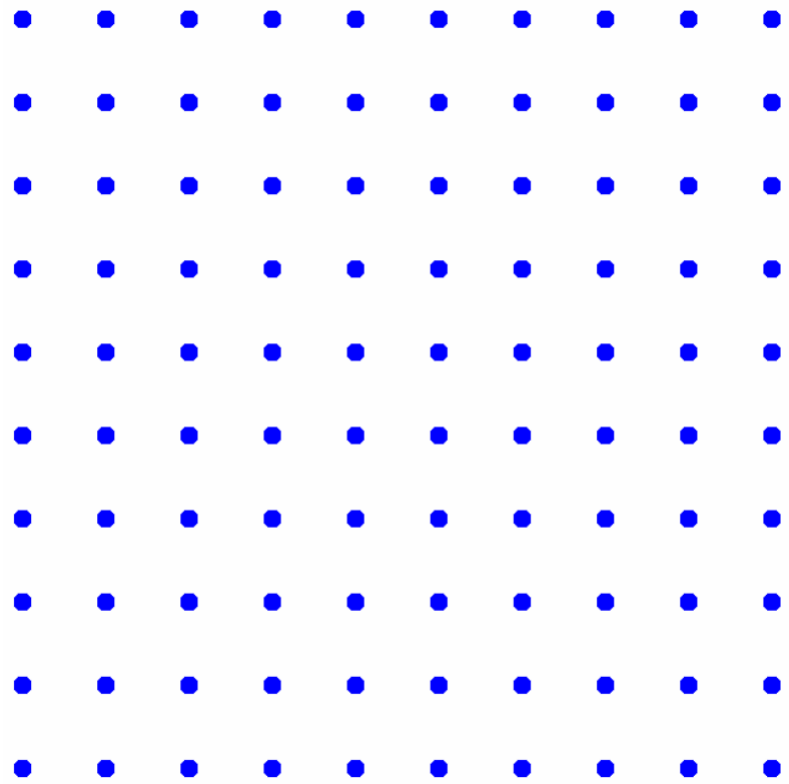
Our Emergence Example (cont.)



Step 6

Our Emergence Example (cont.)

- All dots have the same blue color at step 7
  € no more change after step 7



Step 7