Recap: Pseudocode

- Simple instructions: involve +, -, ×, ÷
- Compound instructions
  - Conditionals
  - Loops

- Exact syntax unimportant (unless it changes meaning of program !)
Algorithm

- Pseudocode for turning a set of inputs into outputs in a **finite** amount of time

- Questions to think about:
  - What class of computational tasks can be solved by algorithms?
  - How dependent is this class on the exact definition of pseudocode?
Conway’s Game of life

- **Rules:** At each step, in each cell
  - **Survival:** Critter survives if it has exactly 2 or 3 neighbors
  - **Death:** Critter dies if it has 1 or fewer neighbors, or more than 3.
  - **Birth:** If cell was empty and has 3 critters as neighbors, new critter is born.

\[
\begin{array}{c}
n \times n \text{ array } A \\
A[i, j] = 1 \text{ means critter lives in square, } 0 \text{ means empty square}
\end{array}
\]
Pseudocode for each step

Do for $i = 1$ to $n$
  {Do for $j = 1$ to $n$
  {
  
  if (Number-of-neighbors = 3) then
    { $B[i, j] ← 1$}
  else {
    if (Number-of-neighbors = 2)
      etc. etc.//see handout//
  }
  }
  }
Do for $i = 1$ to $n$
  {Do for $j = 1$ to $n$
  { $A[i, j] ← B[i, j]$ }
  }
Moral of the Game of Life?

- Simple local behavior can lead to complex global behavior

(cf. Brian Hayes article)
Physics of snow crystals

- “Cooling” – reduce amount of molecular motion
- Crystal growth: capture of nearby floating molecules
Twister simulation

- Divide region into 3D grid
- Identify laws of physics for air

Navier Stokes equations:

How does a block of air move when certain pressure, temperature and velocity differentials exist on its boundary?
Simulator pseudocode

- Initialize Grid using data from observations: surface and aircraft measurements, radar (NEXRAD) readings, etc.

```plaintext
Do for i = 1 to n
{
    Do for j = 1 to n
    {
        Do for k = 1 to n
        { Update state of Grid[i, j, k] }
    }
}
```

10°C, 15 psi, 20% humidity
11°C, 15 psi, 23% humidity
etc.
Other examples of simulation
Question

- How does result of simulation get displayed?

Computer graphics (will discuss in future lecture)

[Burns 05] (Princeton grad student)
Bigger questions

- Can computer simulation be replaced by a “theory of weather”? A “theory of tornadoes”?

- Is there a “theory” that answers following type of problem:
  - Given: A starting configuration in the game of life
  - Output: “Yes” if the cell at position (100, 100) is ever occupied, “No” otherwise
Actually, reverse trend: “theory of matter” (particle physics) is becoming computational.

1670 $F = ma$ etc.

Hayes: The universe as a “cellular automaton”
Another startling fact:

Game of life is actually a “computer.”