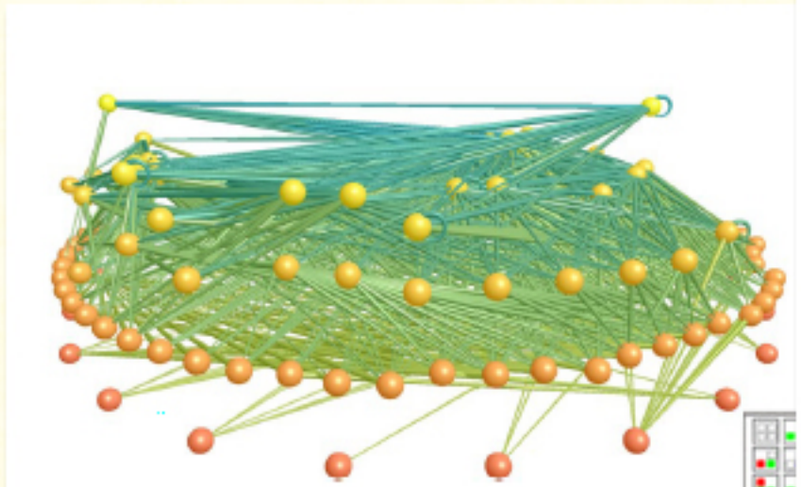
Introduction to Agent-Based Modeling for Social Scientists

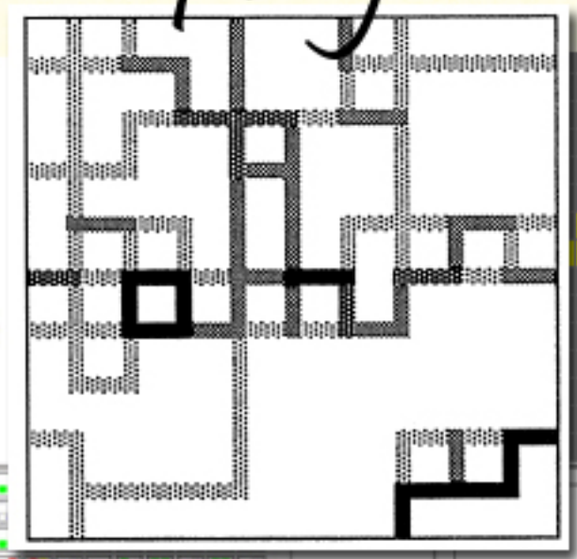
DAY 2

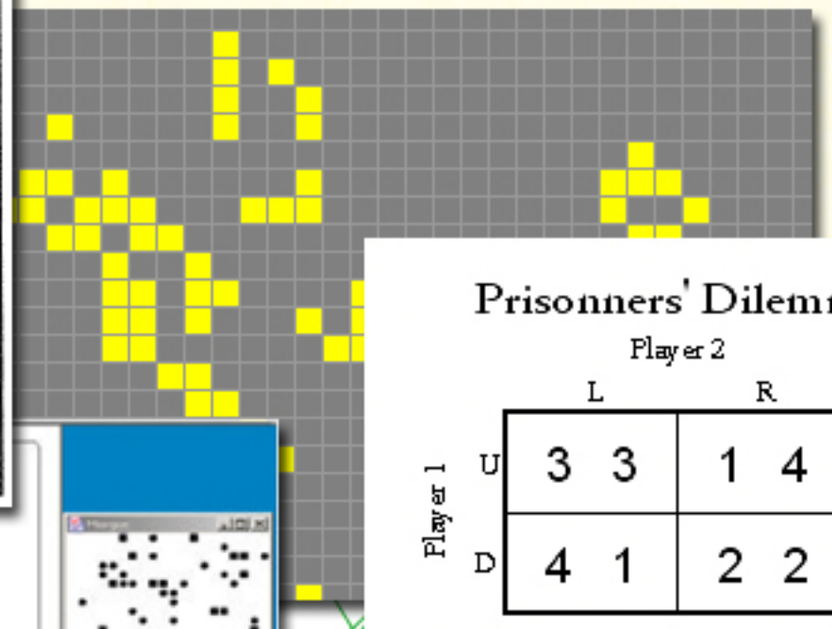
with your host:

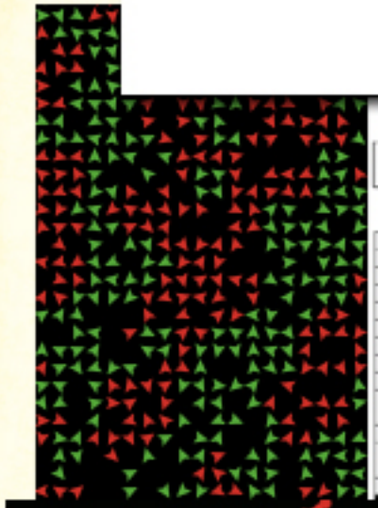
Charles Dorian

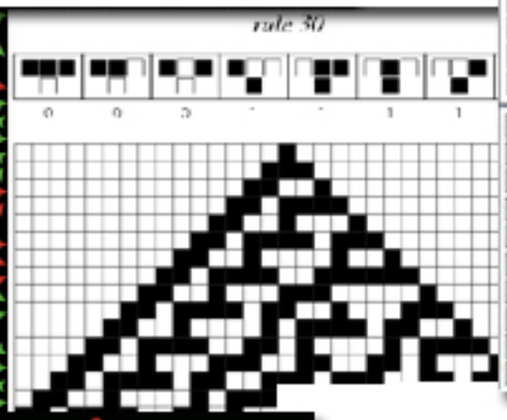
Various Flavors of Agent-Based Models

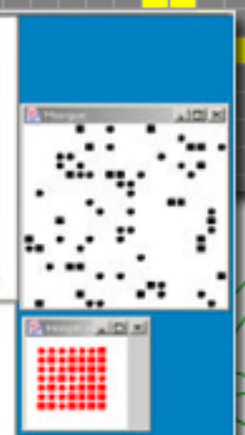


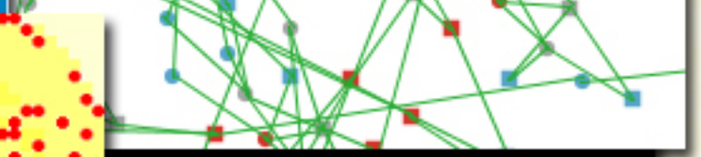


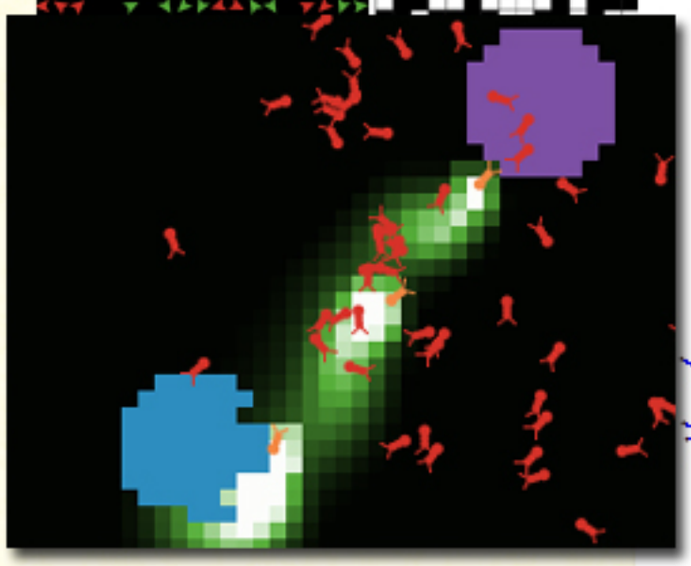


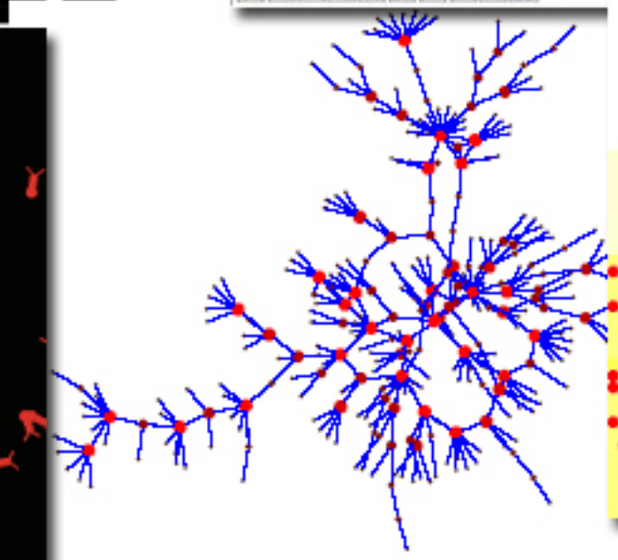


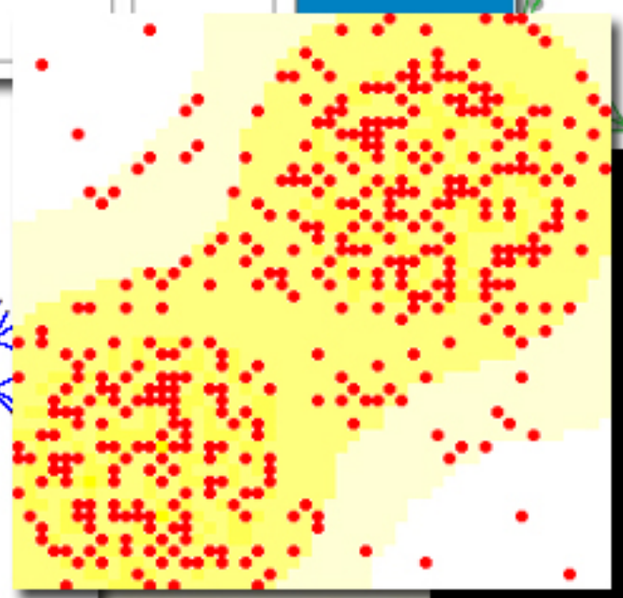


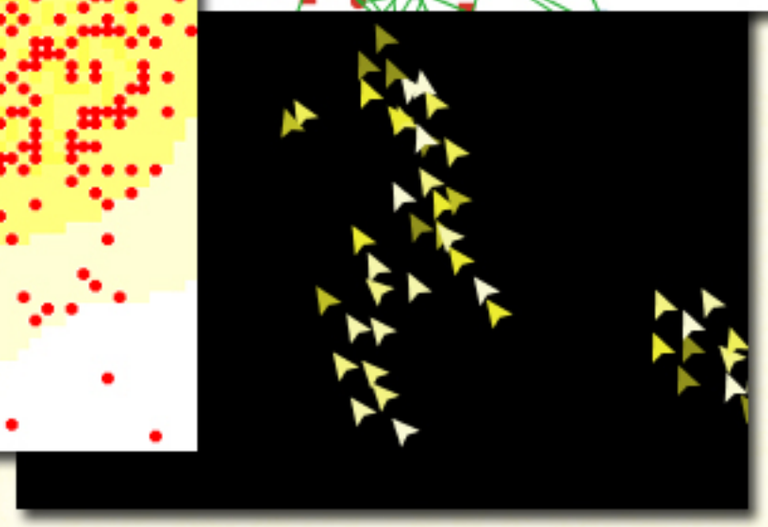












Is an Agent-Based Model What You Need?

What Characteristics of the Behavior are Essential?

- Perspective A: use Occam's Razor - simplest model possible
- Perspective 1: use Kitchen Sink - put in everything
- Complex Systems Exhibit Opaque Attribute Contexts

Which Modelling Techniques(s) Can Capture Them

- Differential Equation Model: dynamic behavior with equillibria
- Statistical Model: predicting behavior through historical analysis
- Analytical Models: equation based with closed form solutions
- Real-World Experiments: scaled-down replica of actual system
- Agent-Based Models: open-ended rule-based computer simulations

Who Will Use the Model and for What?

- Personal Experimentation vs Student Pedagogy
- Prediction, Exploration, Explanation, and/or Existence Proof

What are your Skill/Time Restrictions?

Is an Agent-Based Model What You Need?

Benefits

- Implicit NonLinear Dynamics (Feedback & Dynamic Interactions)
- Spatially Explicit
- Heterogeneous and Adaptable Agents
- "Medium" Number of Agents
- Adaptable/Evolvable System Characteristics
- Exponential Increases in Computer Power
- Plagiarism is Encouraged and Rewarded
- Visualization Can Pump Intuitions and Impress Others

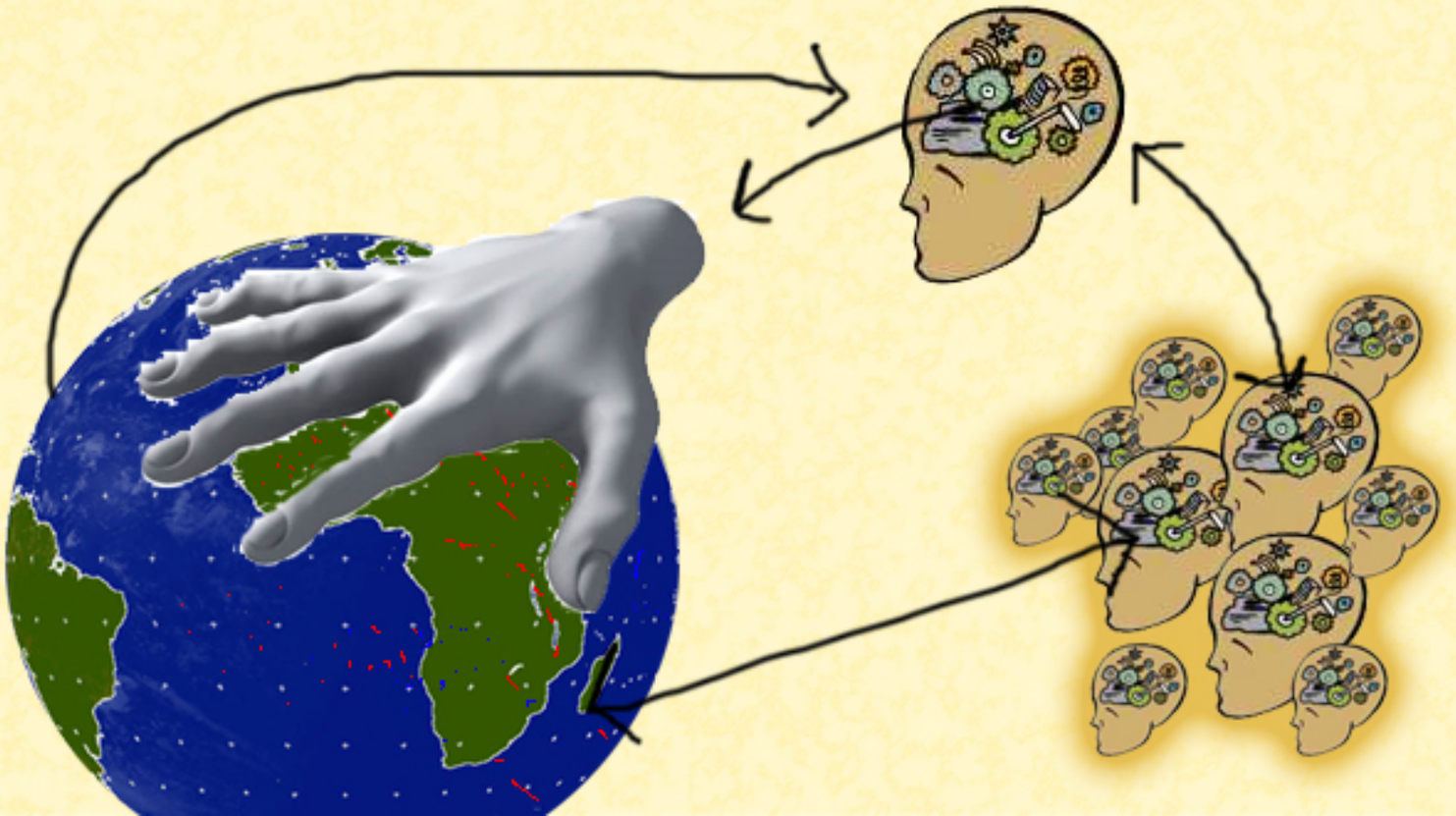
Limitations

- Difficult to Analyze Results and Causal Mechanisms
- Social Stigma Against ABMs
- Practical Limits of Computing Power
- Requires some Computer Programming Ability

Components of Agent-Based Models

Agents

- Rule-Based Behavior (Possibly Learning & Adapting)
- Interact with the World and Each Other
- Between Two and One Duotrigintillion Agents

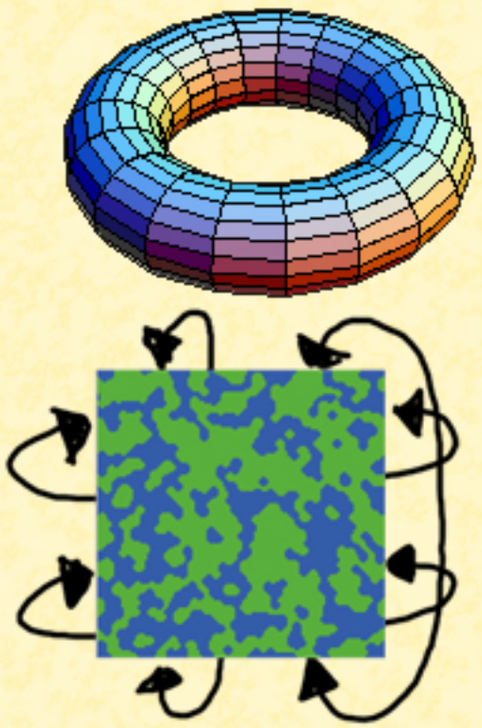


Components of Agent-Based Models

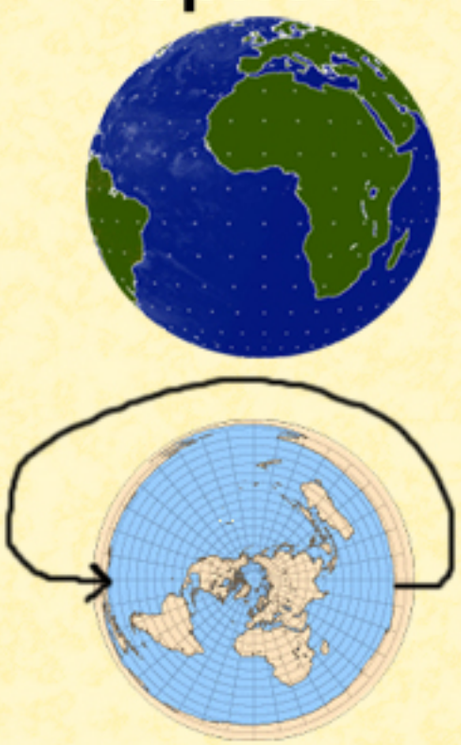
World

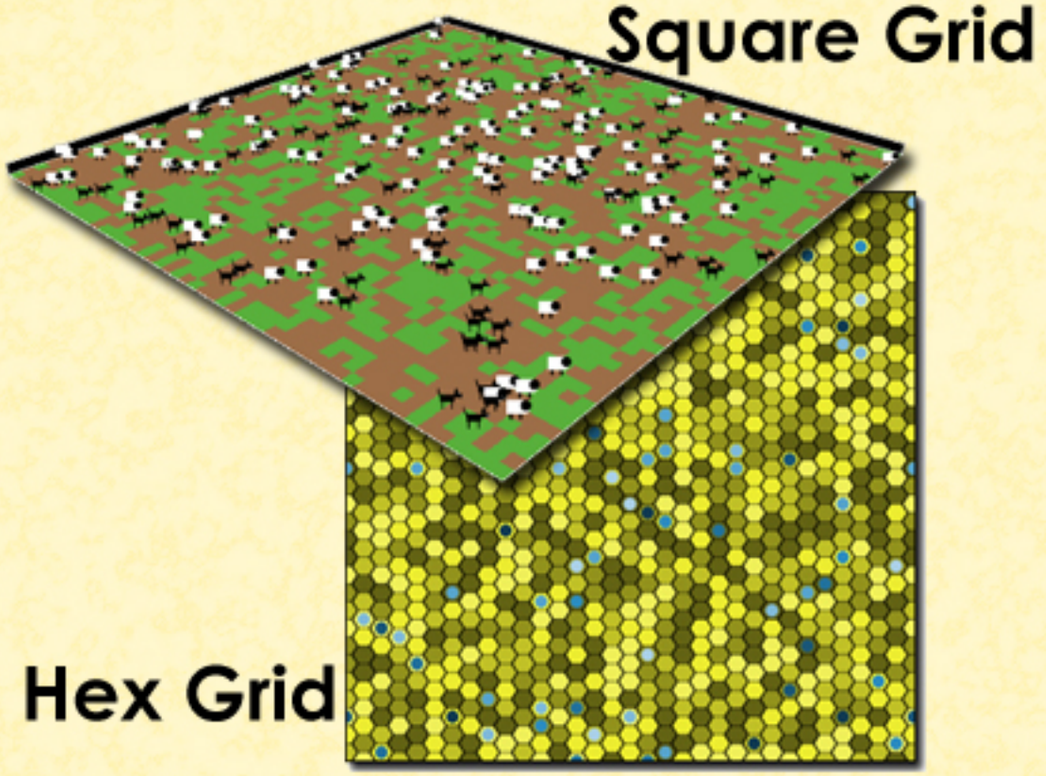
- Pick Your Dimensions: zero through infinity
- Bounded vs Wrapped (Rings and Toroids)
- Holds Values (Environment) which May Be Dynamic
- Divided into Discrete Space or Not

Torus



Sphere

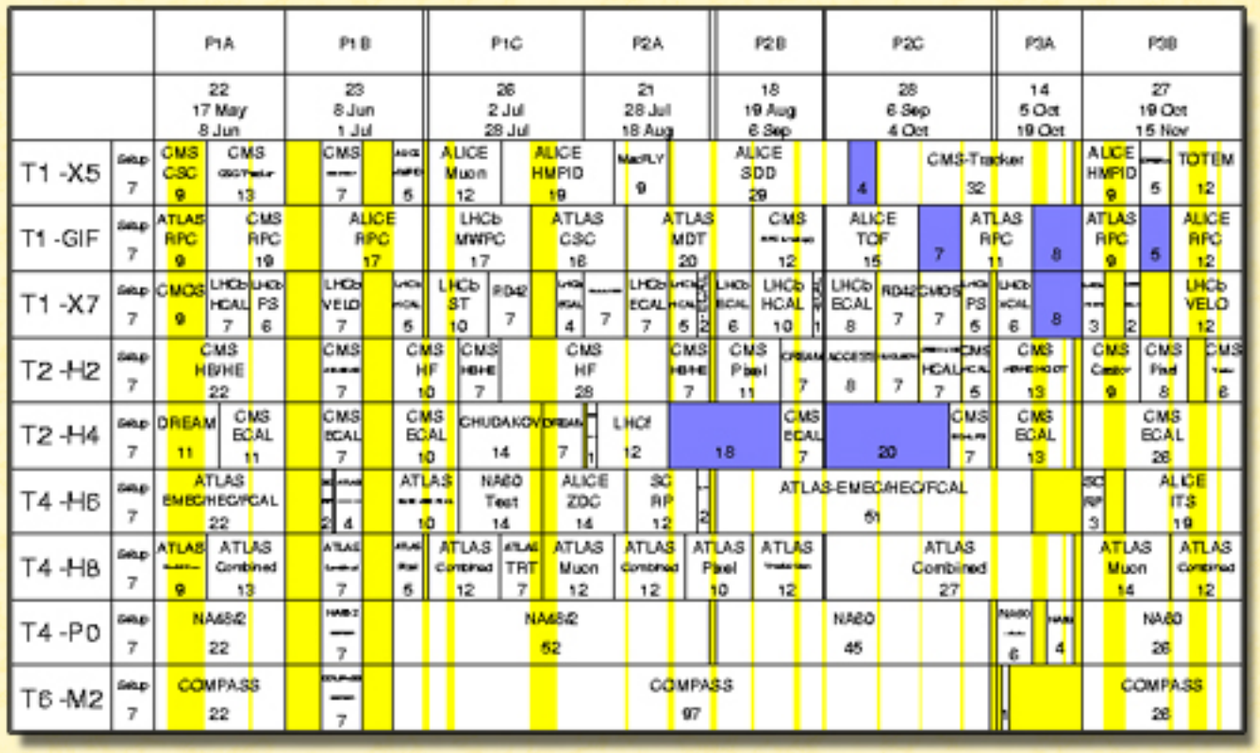




Components of Agent-Based Models

Scheduler

- Determines Order of Execution of Events
- Discrete Time Steps vs Event-Driven Updates
- Synchronous vs Sequential AKA Parallel vs Serial
- How Does the Model Know When It's Done

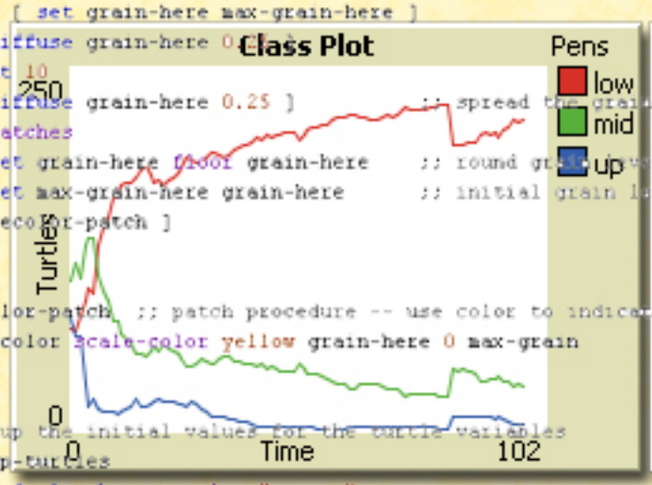


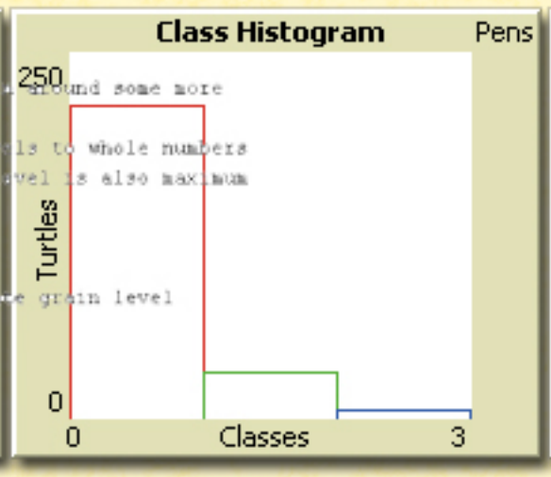
Components of Agent-Based Models

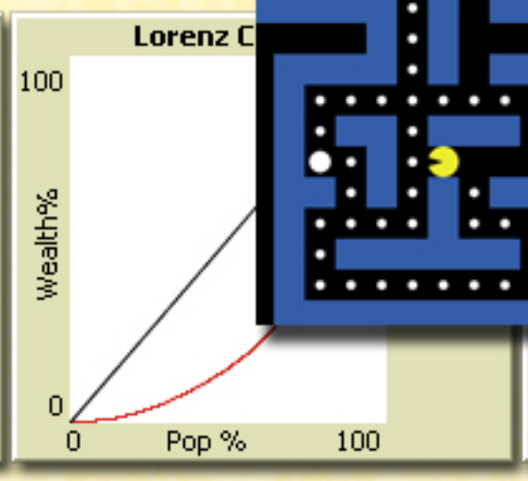
Other Common Elements

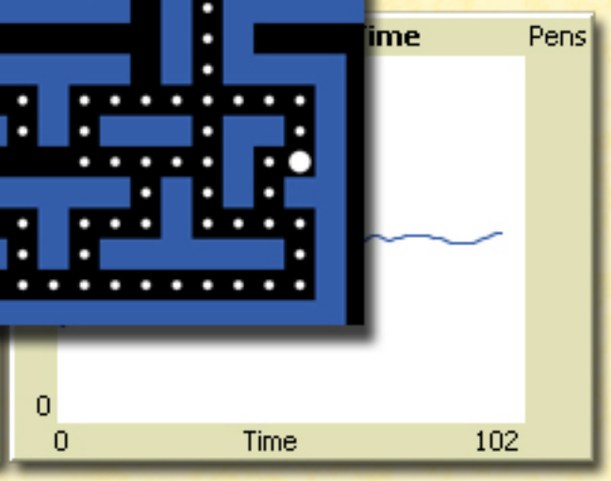
- Resources, Obstacles, Landmarks as "Agents"
- GUI, Graphs, Reports, Documentation, ...

```
;; these patches are the "best land"
ask patches
  [ set max-grain-here 0
    if (random-float 100.0) <= percent-best-land
      [ set max-grain-here max-grain
        set grain-here max-grain-here ] ]
  ;; spread that grain around the window a little and put a little back
  ;; into the patches that are the "best land" found above
  repeat 5
    [ ask patches with [max-grain-here != 0]
        [ set grain-here max-grain-here ]
      diffuse grain-here 0.25 ]
  repeat 10
    [ diffuse grain-here 0.25 ]          ;; spread the grain around some more
  ask patches
    [ set grain-here floor grain-here    ;; round grain levels to whole numbers
      set max-grain-here grain-here      ;; initial grain level is also maximum
      recolor-patch ]
end

to recolor-patch  ;; patch procedure -- use color to indicate grain level
  set pcolor scale-color yellow grain-here 0 max-grain
end

;; set up the initial values for the turtle variables
to setup-turtles
  set-default-shape turtles "person"
  no-display  ;; so we don't see the turtles until they're recolored
  crt num-people
    [ setxy (random screen-size-x)
            (random screen-size-y)
      set size 1.5  ;; easier to see
      set-initial-turtle-vars
      set age random life-expectancy ]
  recolor-turtles
  display
```









What are Agents Based Models Made of?

Space and Movement

- Space Measure (e.g. Distance) in 1D, 2D, or absent?
- Exogenous vs Endogenous Movers (Preferences vs Wind)

Complicated Agents

- CAs and Pure Networks Limit Agent Abilities
- Learning vs Adapting vs Evolving
- Agents using AI and internal models

Model Dynamics

- Agent Birth and Death
- Agents Exchanging Resourses and Information
- Agent-Environment Feedback

What are Agents Based Models Made of?

User-Defined

- Set by users during setup or dynamically
- Initial Conditions or Boundaries
- Takes a Range of Values (Sweepable)
- Define Range and Granularity

"Tweaked"

- Hidden Parameters (Hard-Coded)
- Set at Values that are Known to "Work"

Distribustions

- Select Type of Distribution (Normal, Exp,...)
- Select Distribution Parameters