Computational Modeling of Social Behavior

Day 1

Introduction

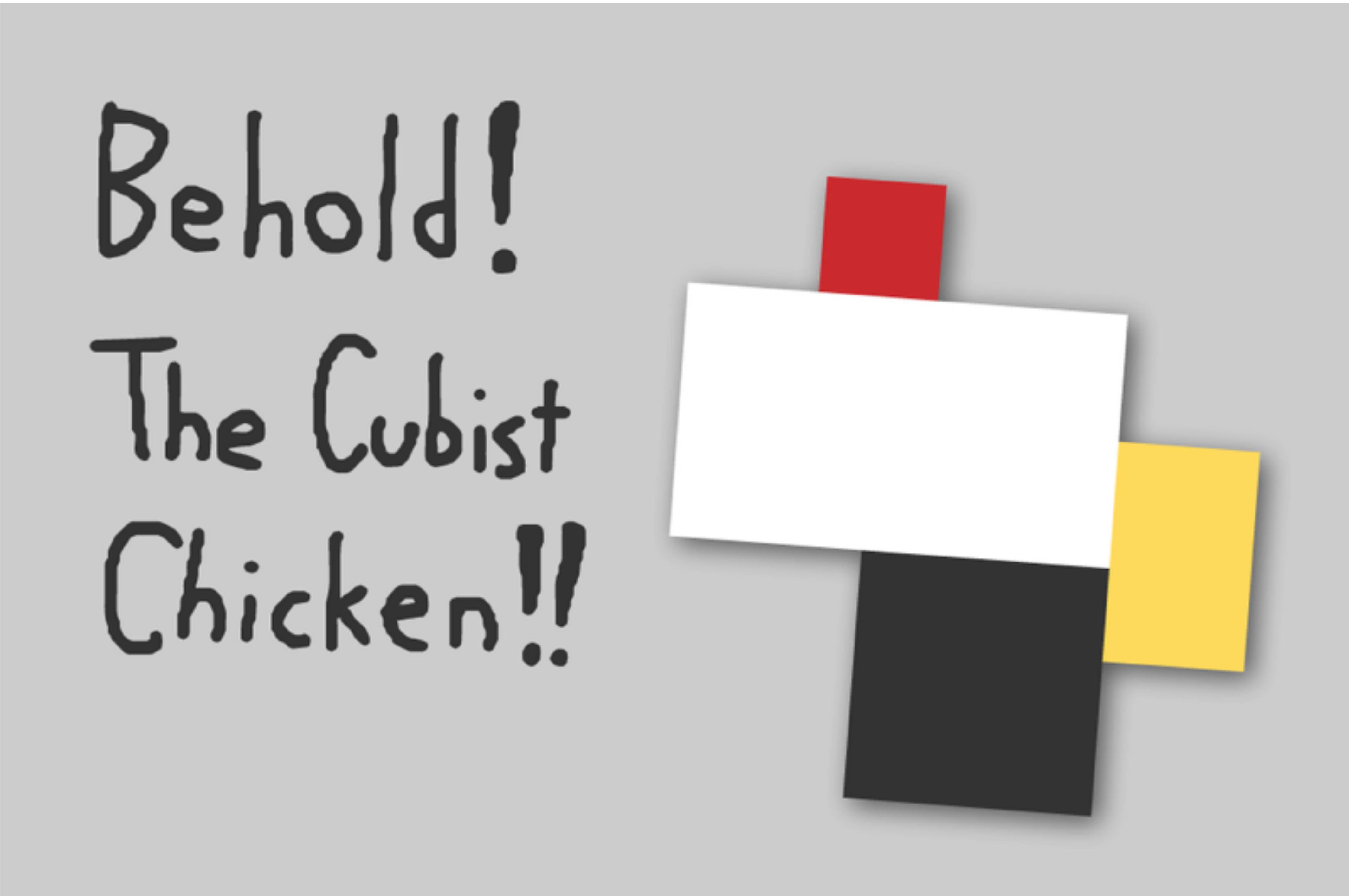
Paul Smaldino

Outline of the course

- Day 1: Introduction to Models and NetLogo
- Day 2: Spreading Infection
- Day 3: Cooperation
- Day 4: Networks
- Day 5: Individual Meetings

Outline of the day

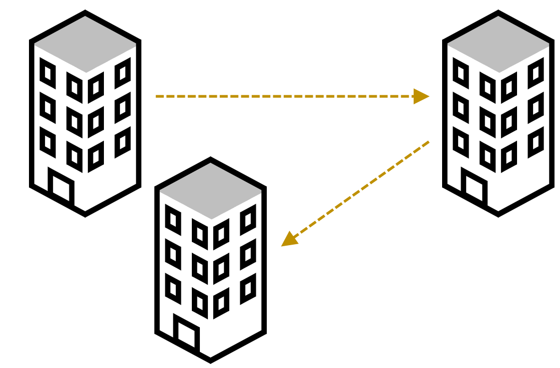
- **Morning**
  - Introductions
  - Models and Modeling
  - NetLogo
- **Afternoon**
  - NetLogo continued
  - Modeling Challenges



Drawing by Nicky Case @ncasenmare

Hypothesis testing and the articulation of parts

- We want to explain some behavior of some system

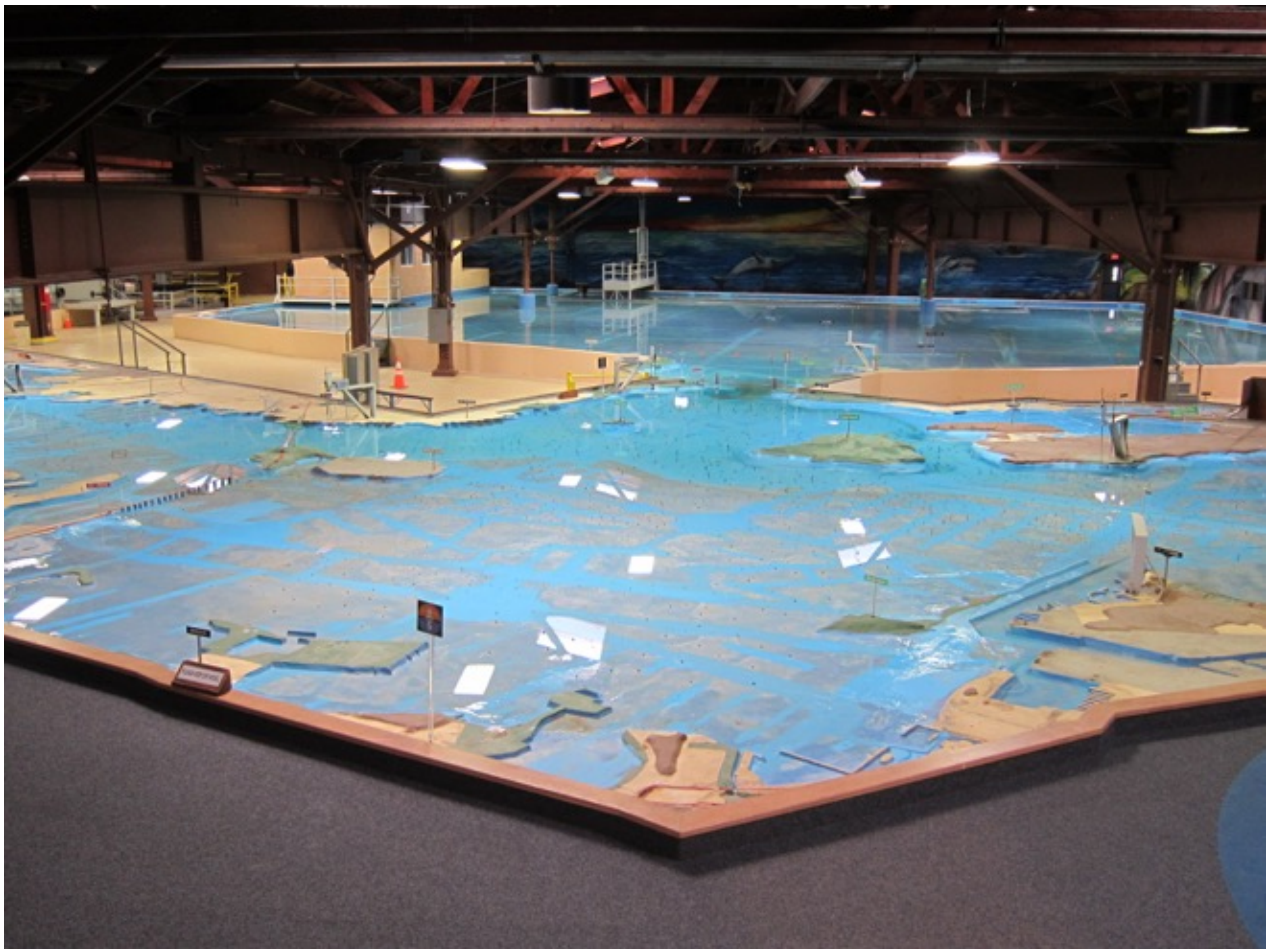


- A system can be decomposed into parts and interactions between those parts

- No single best decomposition for a system. Depends on your question.

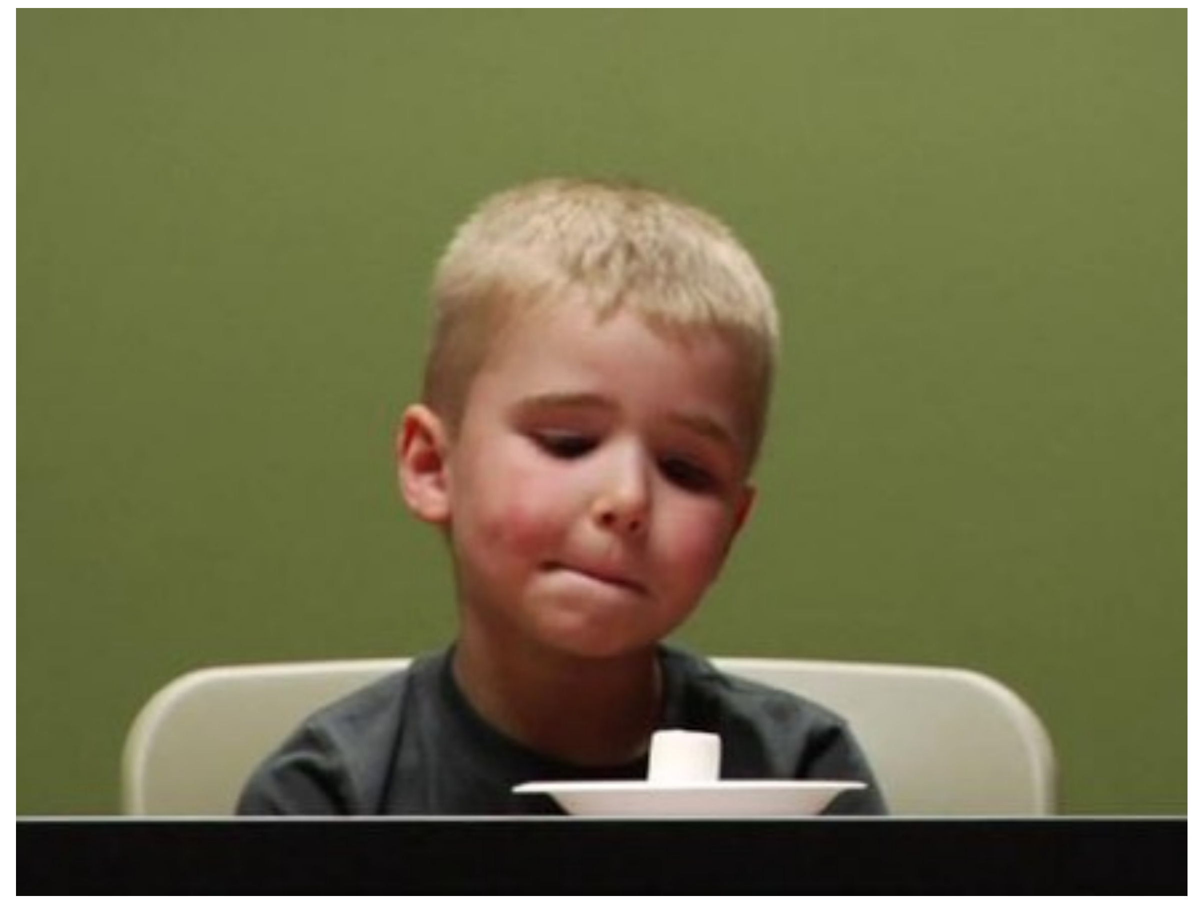
Models

Abstract structures or physical structures that can potentially represent real-world phenomena.



Models

Abstract structures or physical structures that can potentially represent real-world phenomena.



Models

Abstract structures or physical structures that can potentially represent real-world phenomena.

$+$

$-$

Lynx eat hares. More lynx means fewer hare

$+$

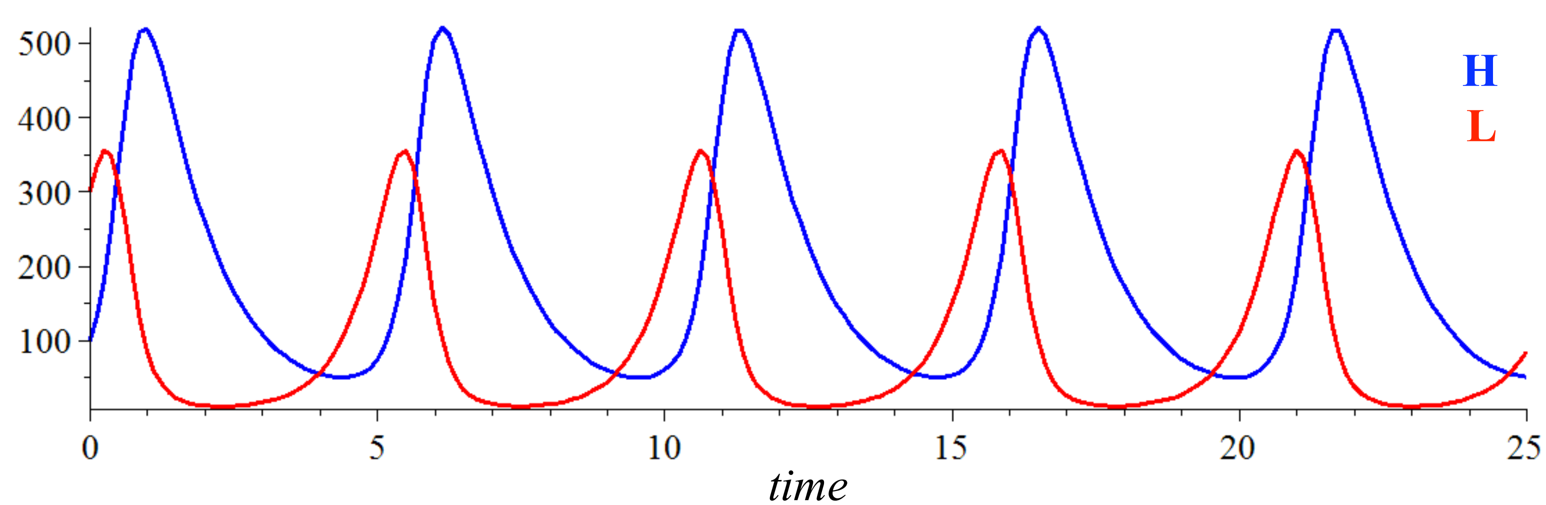
Hares reproduce in the absence of predators

$-$

Lynx die/migrate in the absence of prey.

$$\frac{dH}{dt} = aH - bHL$$

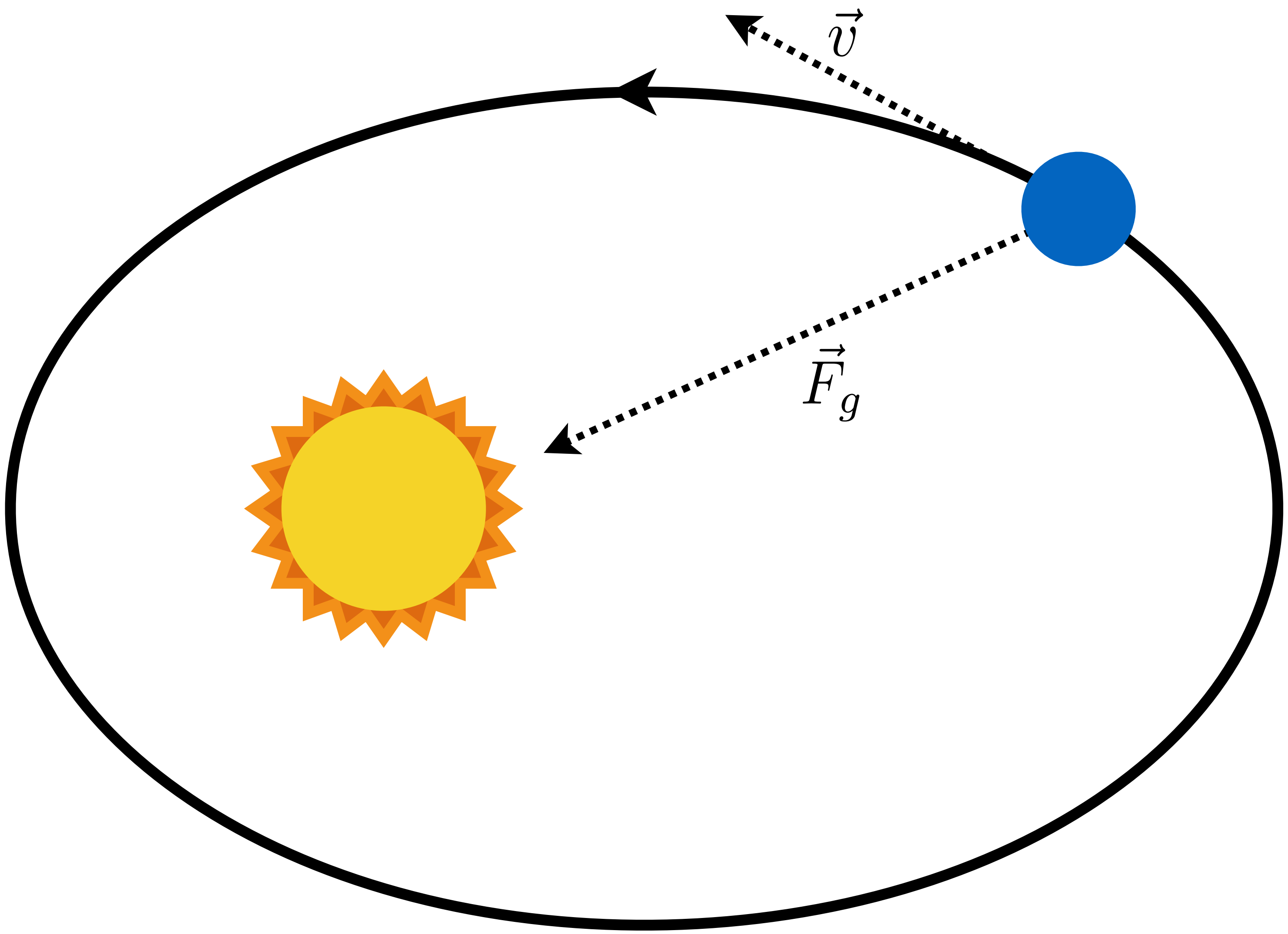
$$\frac{dL}{dt} = cHL - dL$$



Why use models?

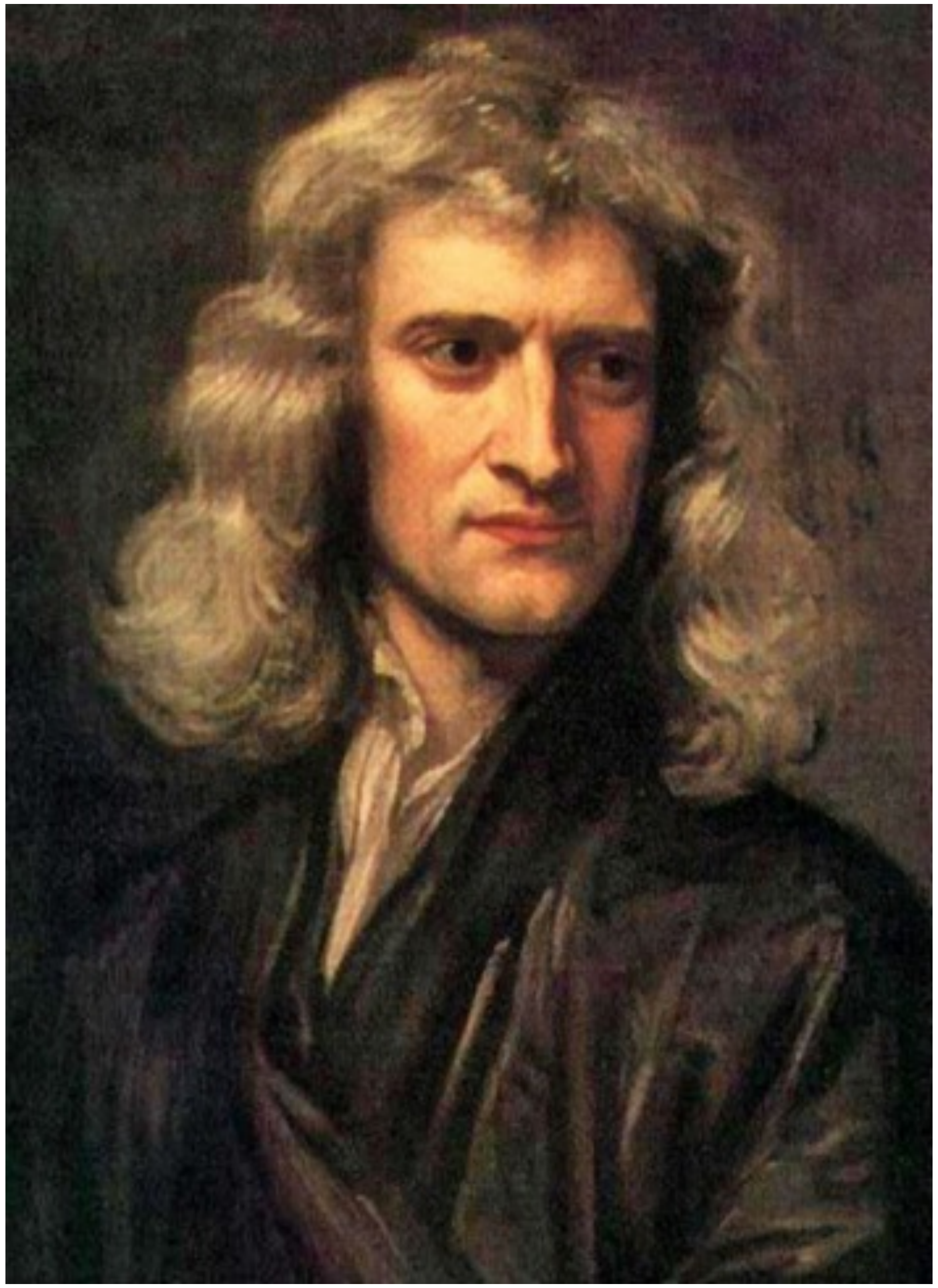
- Examine the clarity of our hypotheses
- Explore the consequences of our assumptions
- Explore imagined or counterfactual scenarios
- Make predictions
- Identify questions for empirical research
- Deepen our understanding of the world

Example: Universal Gravitation

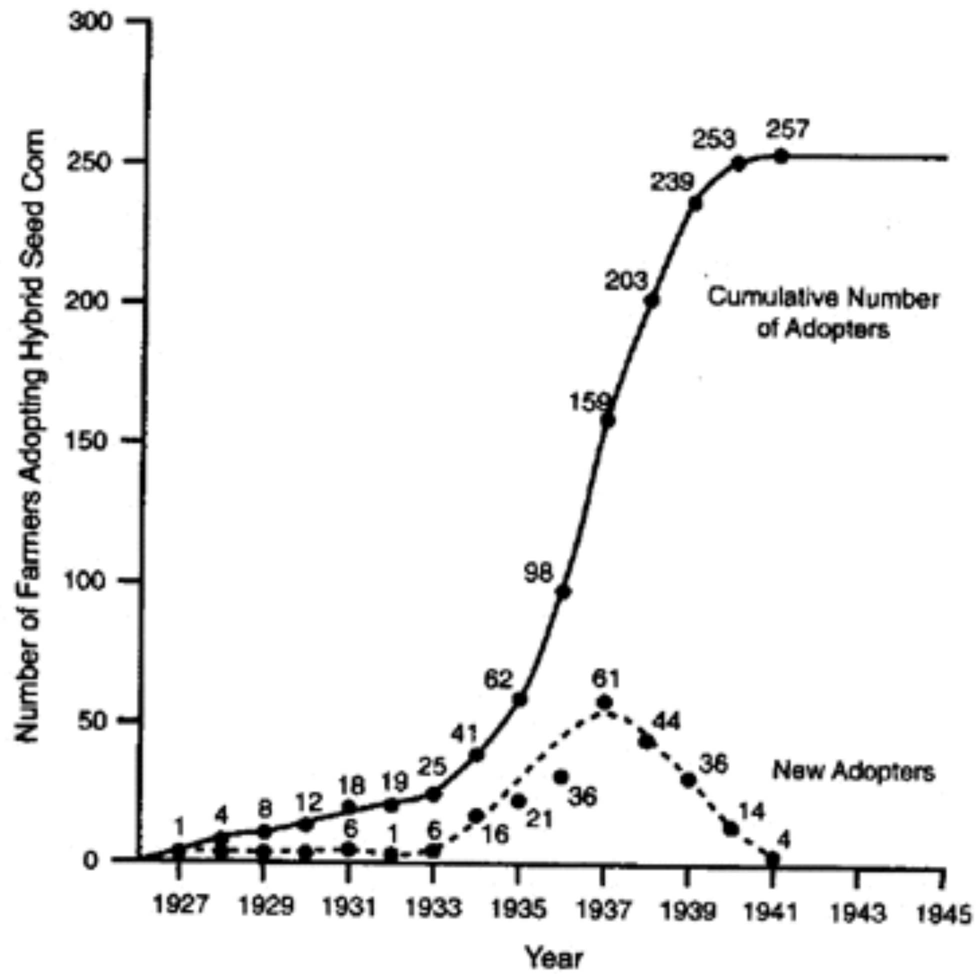


$$\vec{F}_g \propto \frac{m_1 m_2}{r^2}\hat{r}$$

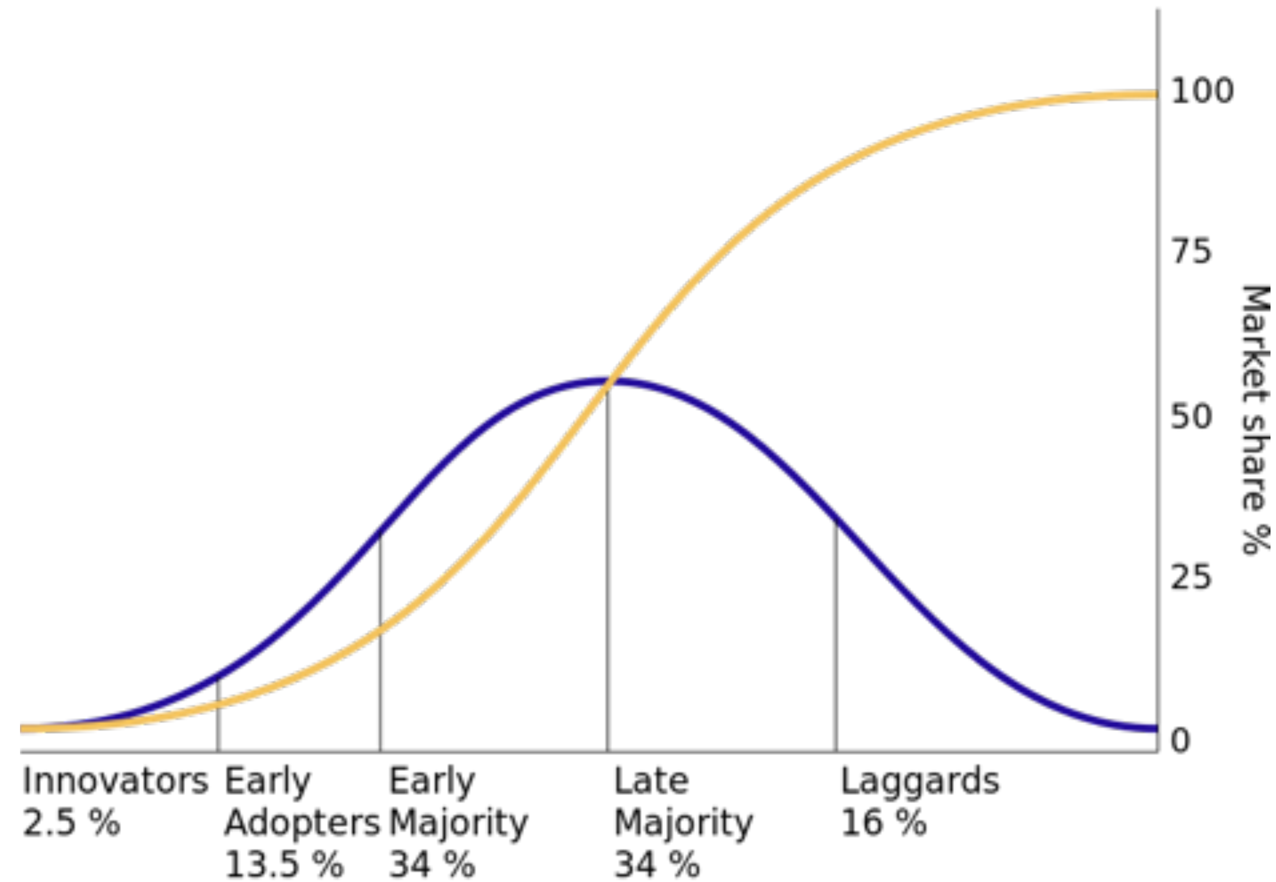
$$\vec{F} = m\frac{d\vec{v}}{dt}$$



Example: Diffusion of Innovations



Ryan and Gross (1943)



Rogers (1962)

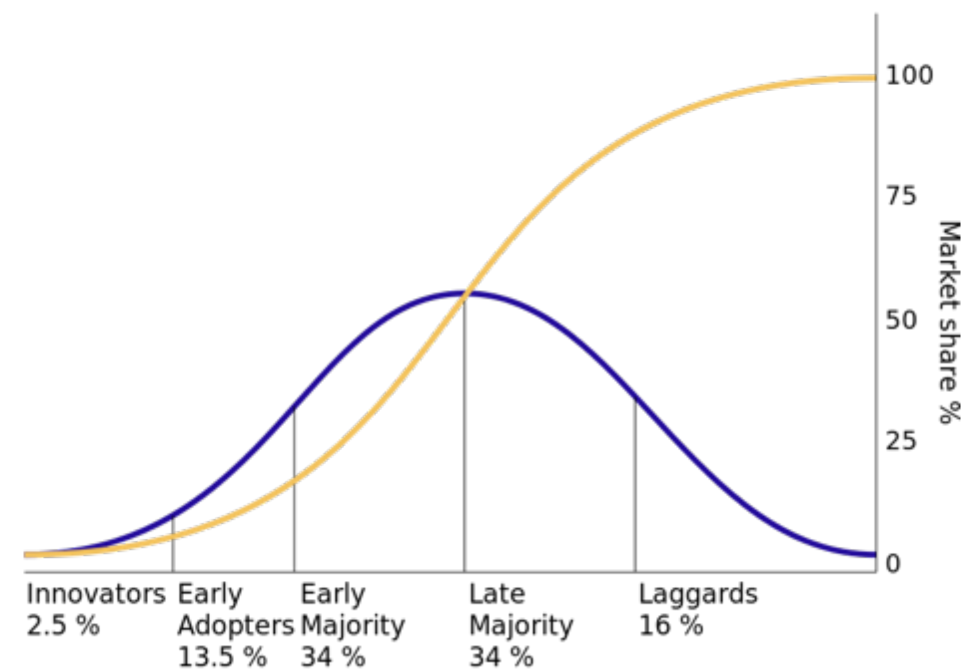
Categories are tautological

Example: Diffusion of Innovations

- Bass (1969)
  - Based on epidemiological models
  - Designed to explain timing of adoption

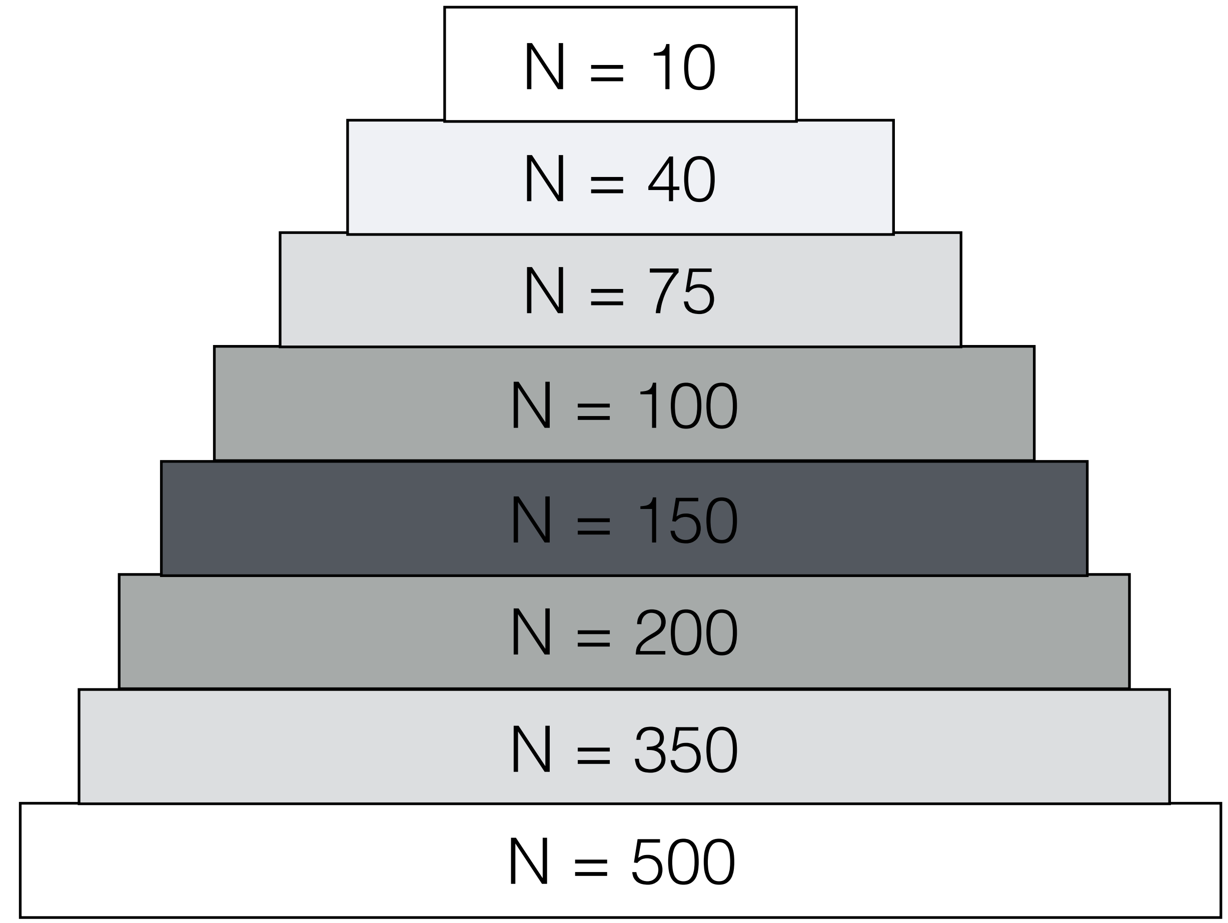
$$\frac{dN(t)}{dt} = p[m - N(t)] + \frac{q}{m}N(t)[m - N(t)]$$

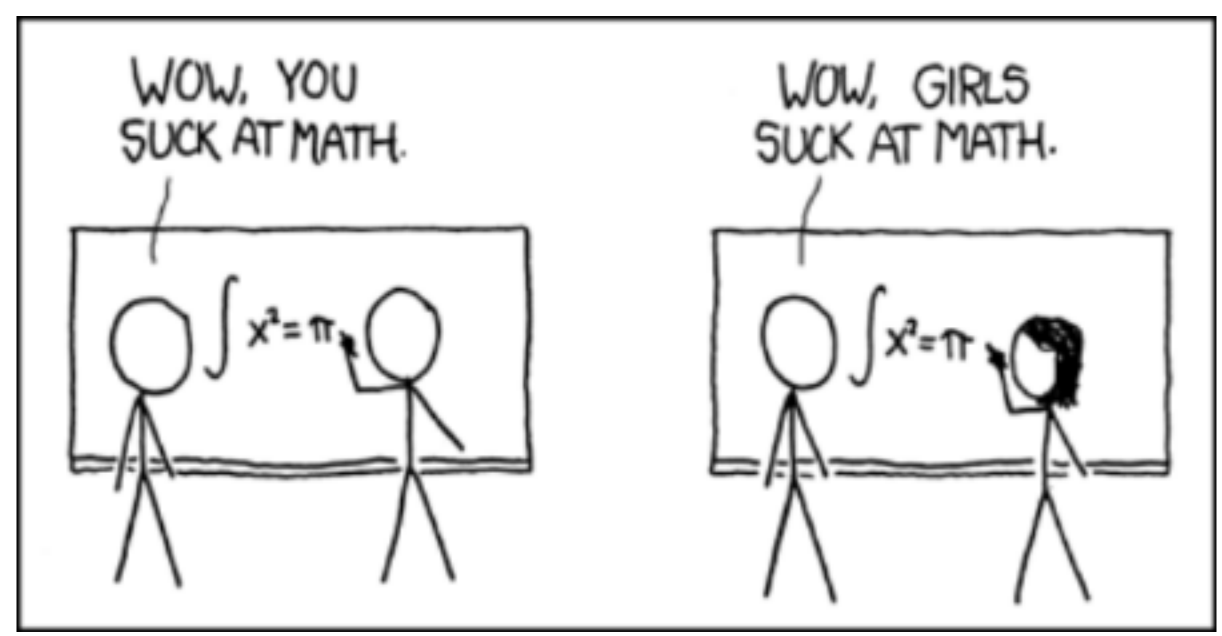
- Assumptions:
  - All individuals are either innovators or imitators
  - Innovators adopt with a constant probability, ignoring others
  - Imitators adopt with a probability that is a linear function of the current number of previous adopters.



Example: Bias in the Workplace

- Hierarchical organization (8 levels)
- Initially 50% women at each level
- Individuals have value drawn from normal distribution with same mean, SD for all
- Men’s values are perceived to increase by X% of the variance
- Over several rounds, 15% of employees left, and top performers at next lowest level filled their place

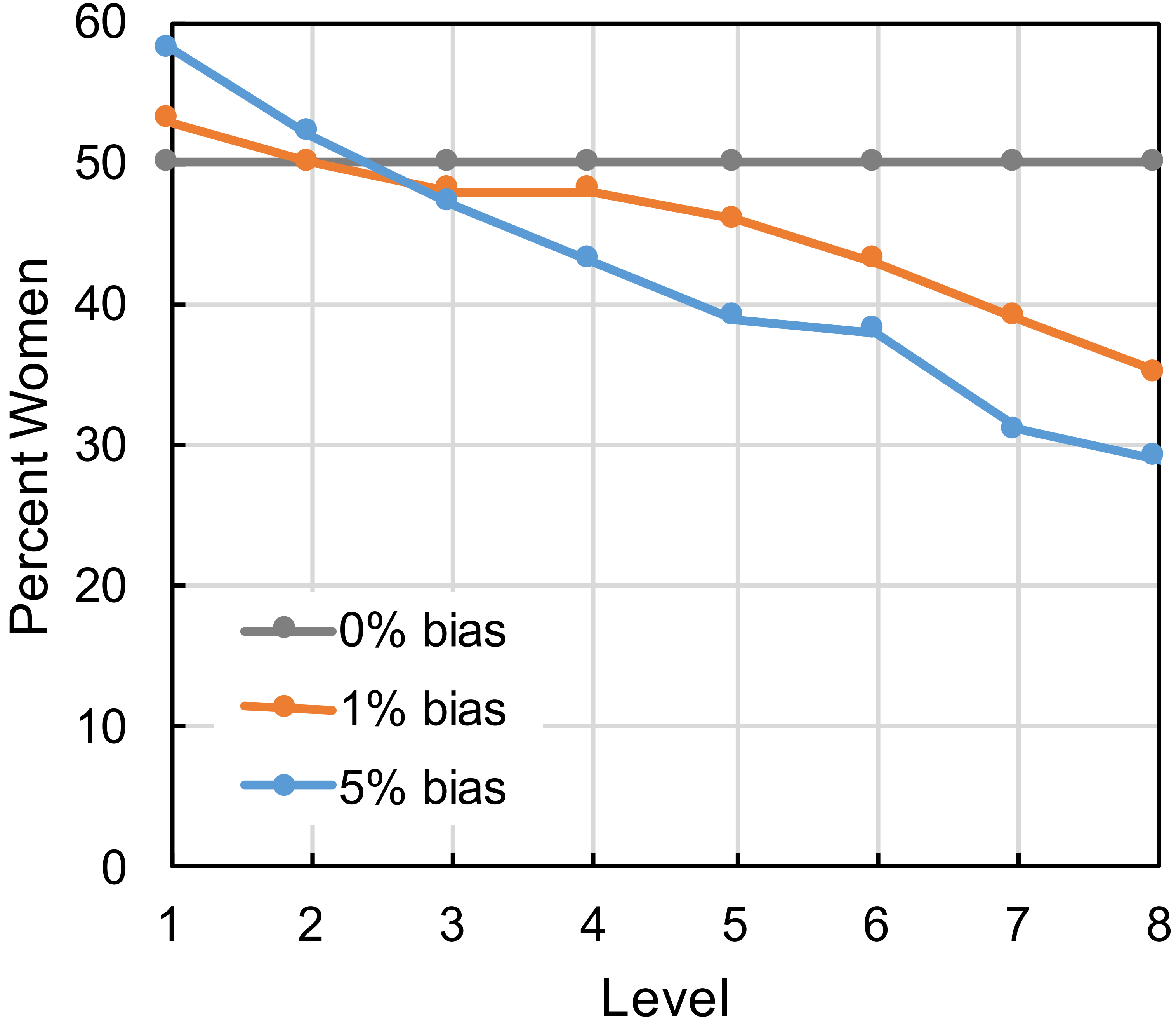




XKCD

Martell et al. (1996)

Example: Bias in the Workplace



Martell et al. (1996)

See also: http://doesgenderbiasmatter.com/

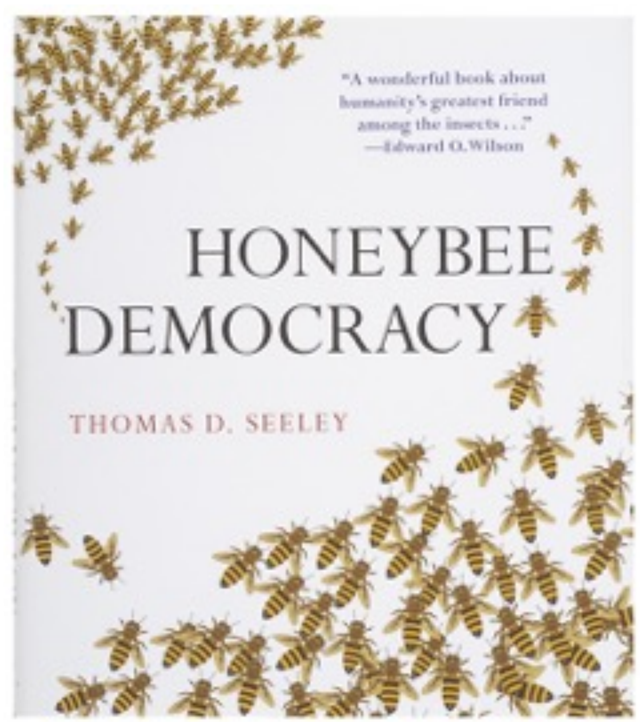
Agent-based models

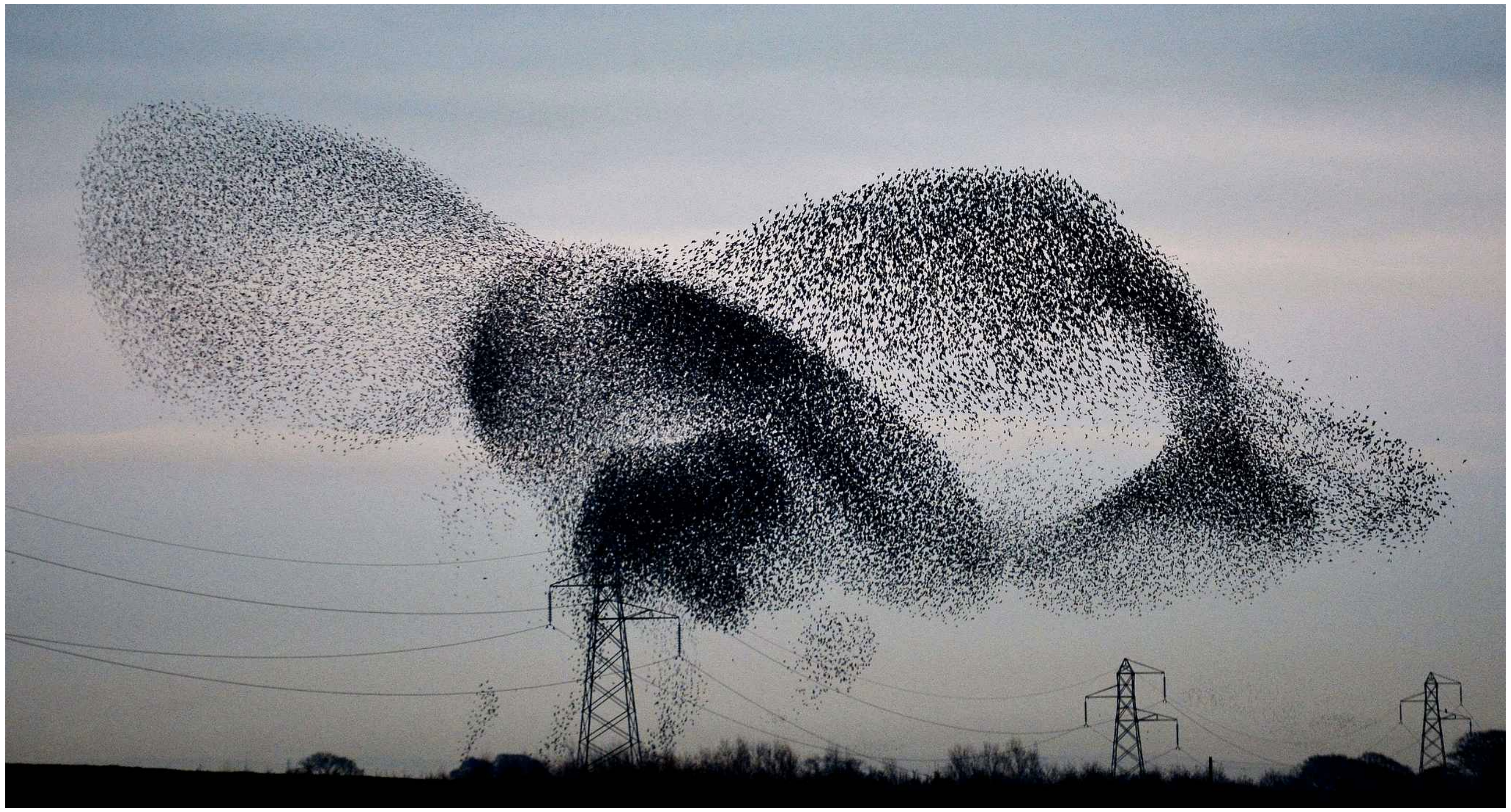
- A type of formal model in which individuals (agents) are simulated as explicit computational entities
- Costs: Analytical tractability, easy parameter exploration
- Benefits: Can account for greater complexity, heterogeneity, and structure. Can help us to understand emergent phenomena.
- Tradeoff relative to research questions being asked

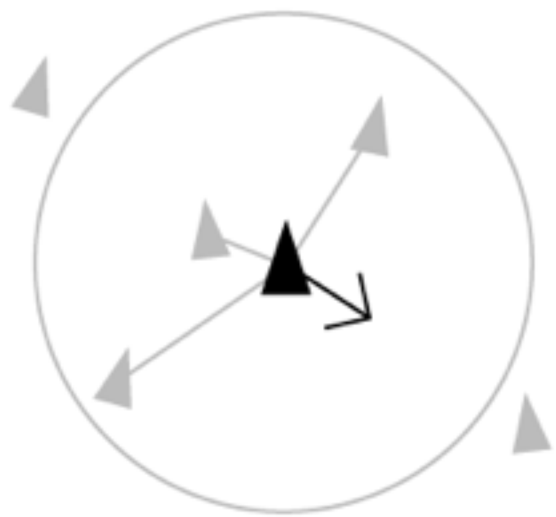
Emergence

Working definition:

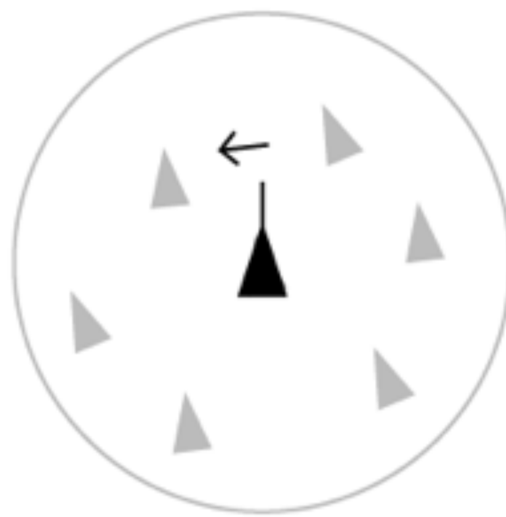
A phenomenon is ***emergent*** when the language of the more primitive concepts and relationships among its parts fails to capture the phenomenon at hand.



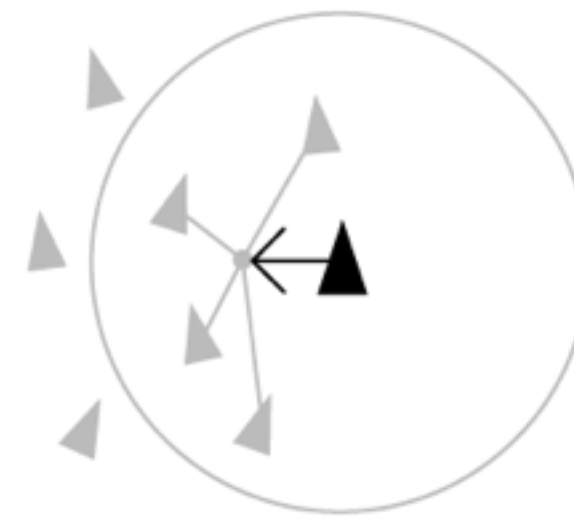




Separation:
Steer to avoid crowding local flockmates

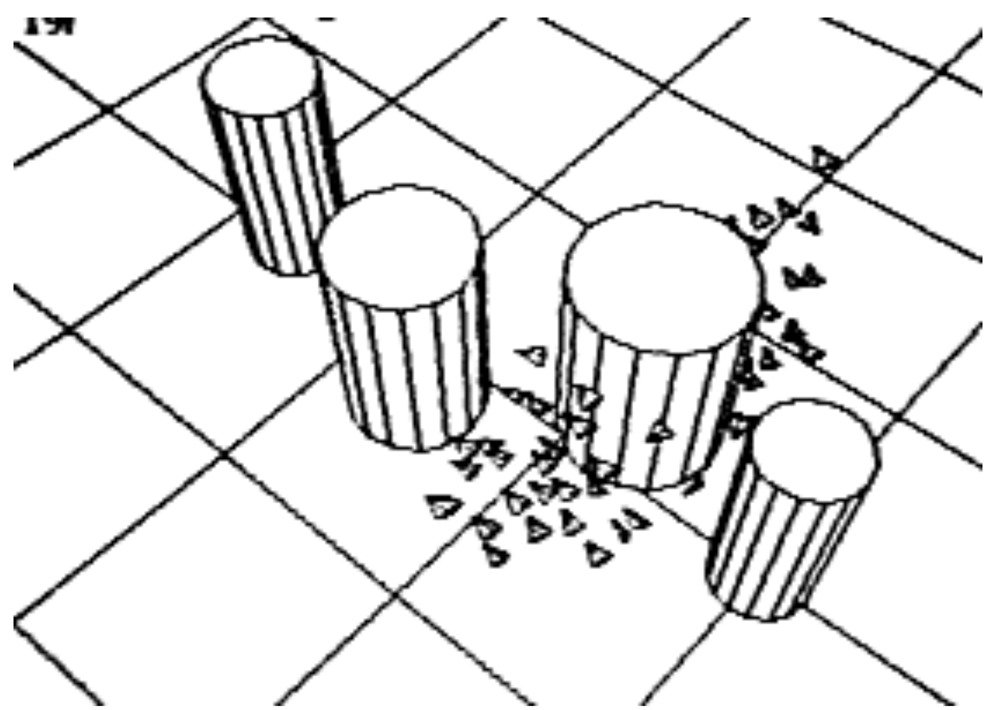


Alignment:
Steer toward the average heading of local flockmates



Cohesion:
Steer to move toward the average position of local flockmates

Craig Reynold's 'Boids'



https://youtu.be/M028vafB0l8

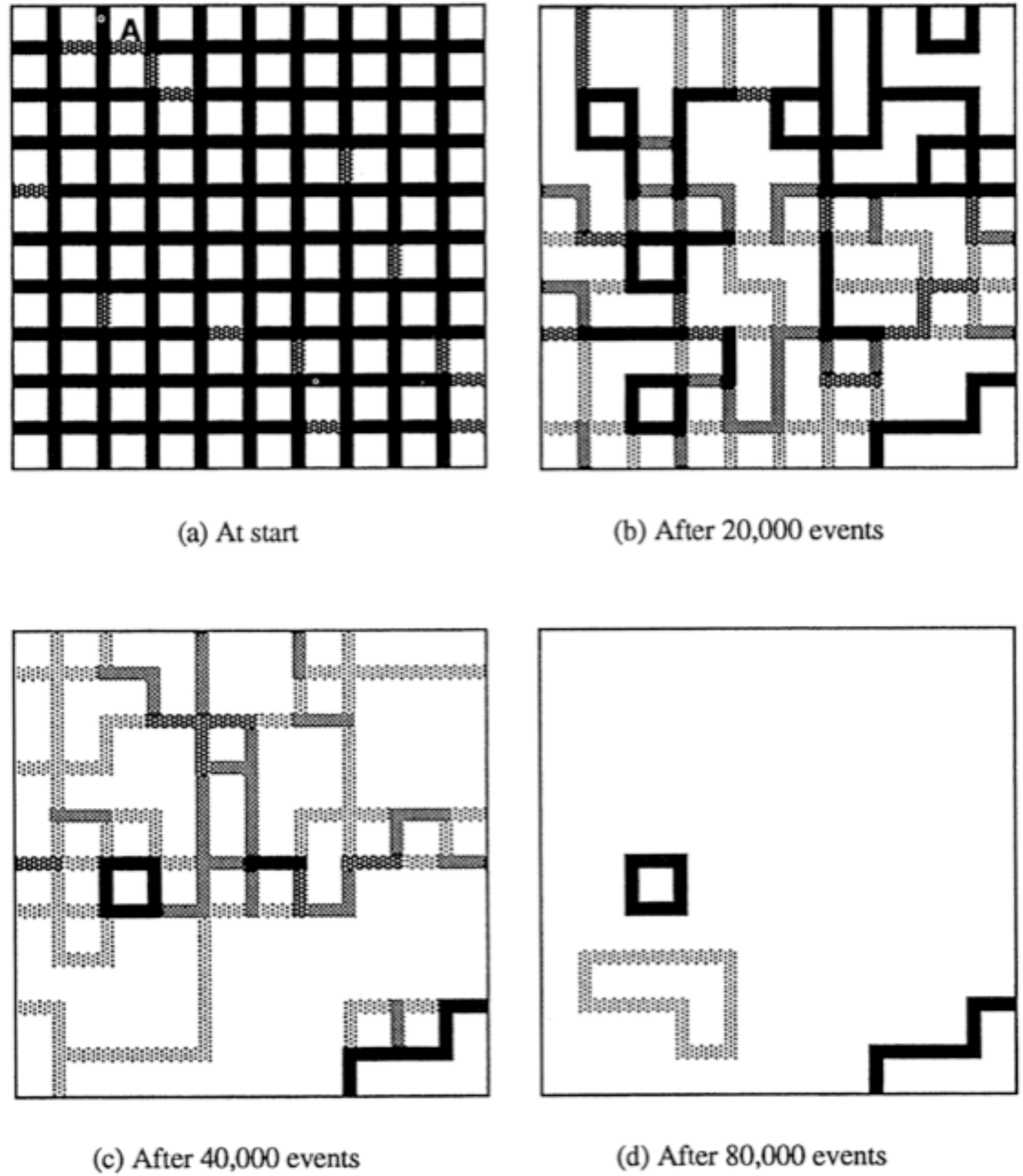
Social dynamics: Understanding cultural boundaries

- Axelrod's culture model
- Empirical pattern: Cultural groups are internally similar but maintain differences with others.
- Individual assumptions:
  - Agents interact preferentially with similar others (homophily)
  - Interaction leads to increased similarity (influence)

- Each individual is defined by a set of F cultural features, each of which can be filled by one of T traits.

- For example, $F = 4$ and $T = 2$, three individuals might look like this:
  - A = {0, 1, 1, 0}
  - B = {1, 1, 1, 0}
  - C = {1, 0, 0, 1}

- Dynamics:
  - Neighbors interact with probability proportional to their similarity
  - Interactions cause one individual to change a trait to match the other.



(a) At start

(b) After 20,000 events

(c) After 40,000 events

(d) After 80,000 events

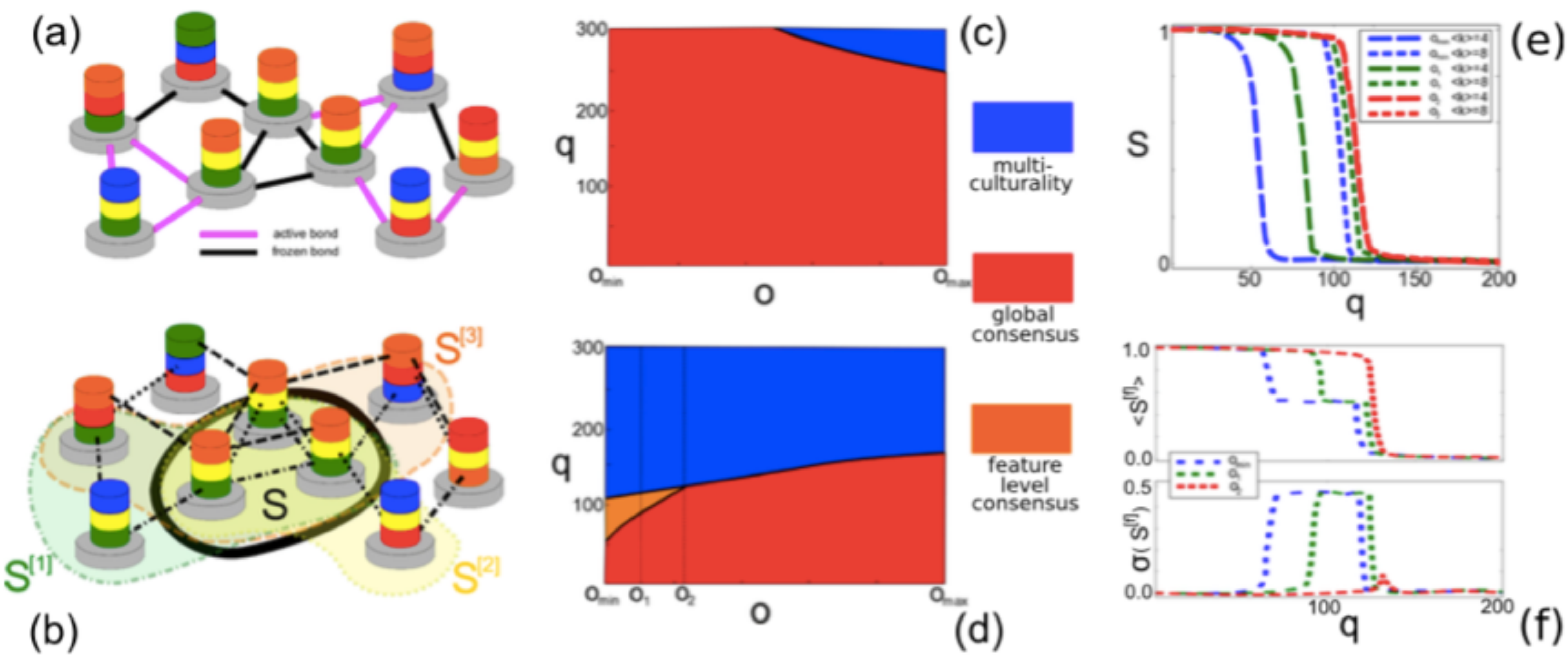
Axelrod R (1997) J. Conflict Res.

SCIENTIFIC REPORTS

OPEN

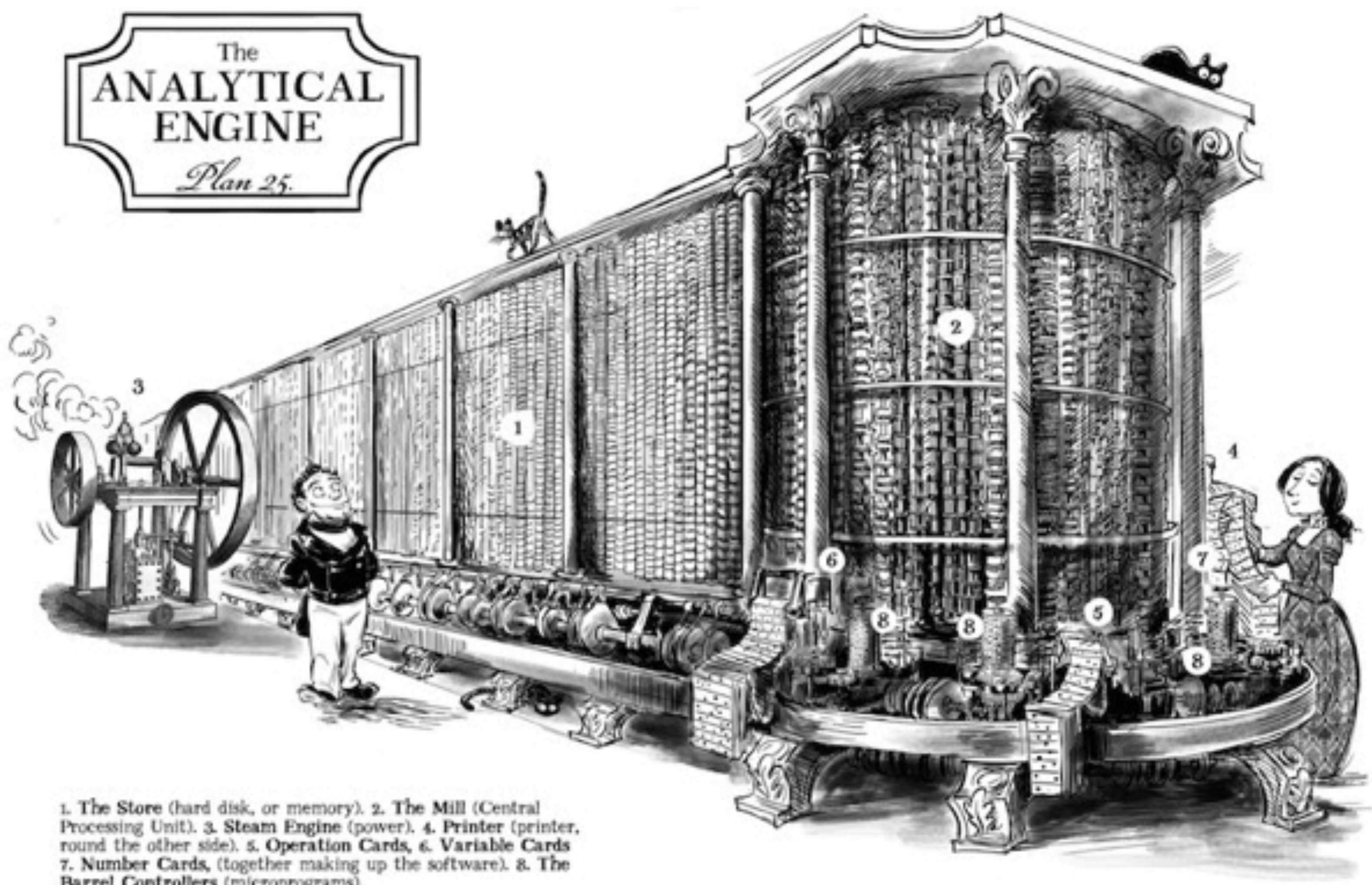
Layered social influence promotes multiculturality in the Axelrod model

Federico Battiston[1], Vincenzo Nicosia[1], Vito Latora[1] & Maxi San Miguel[2]

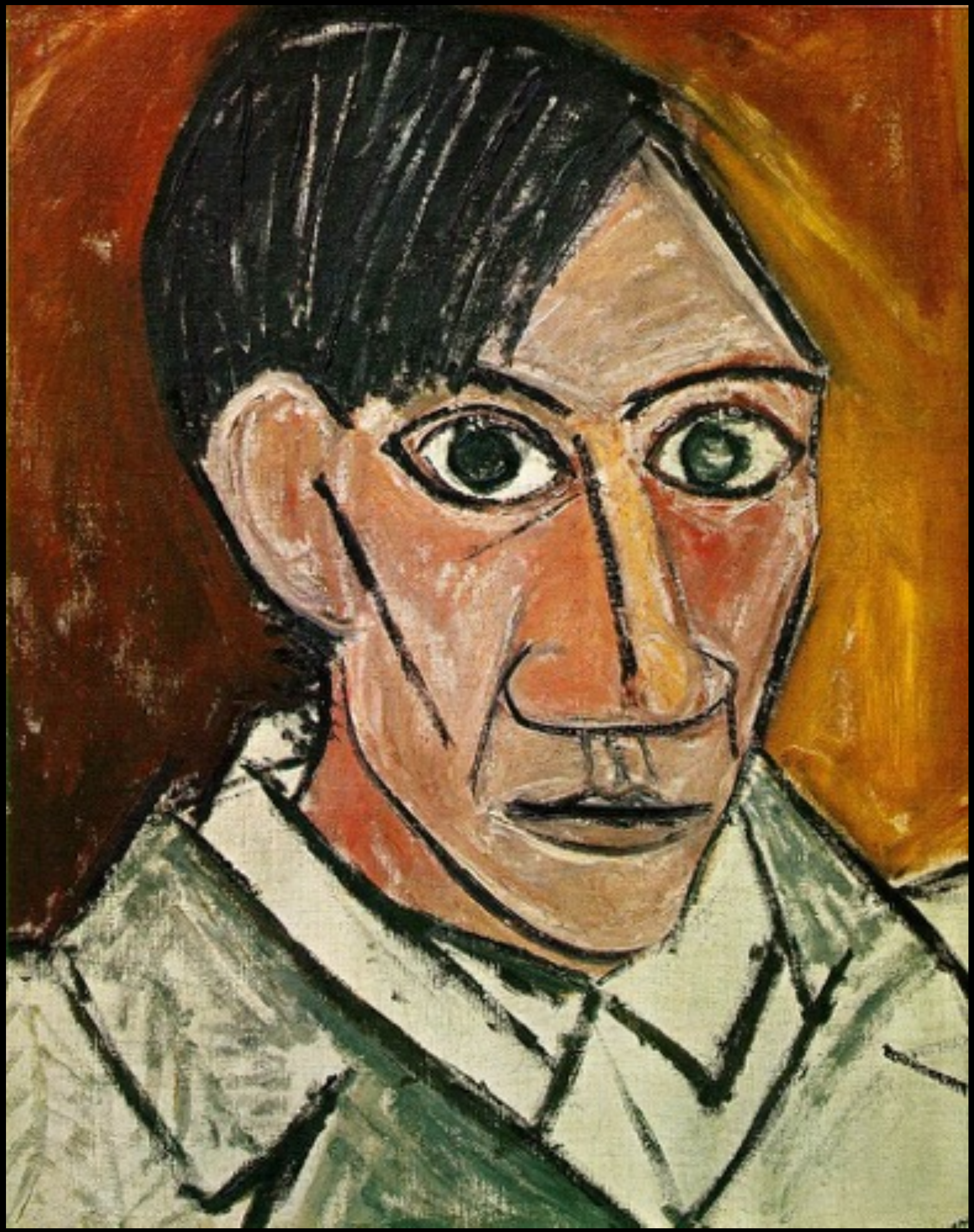


"A model is a logical machine for converting assumptions into conclusions."

–Jeremy Gunawardena (2014)



Padua (2015)

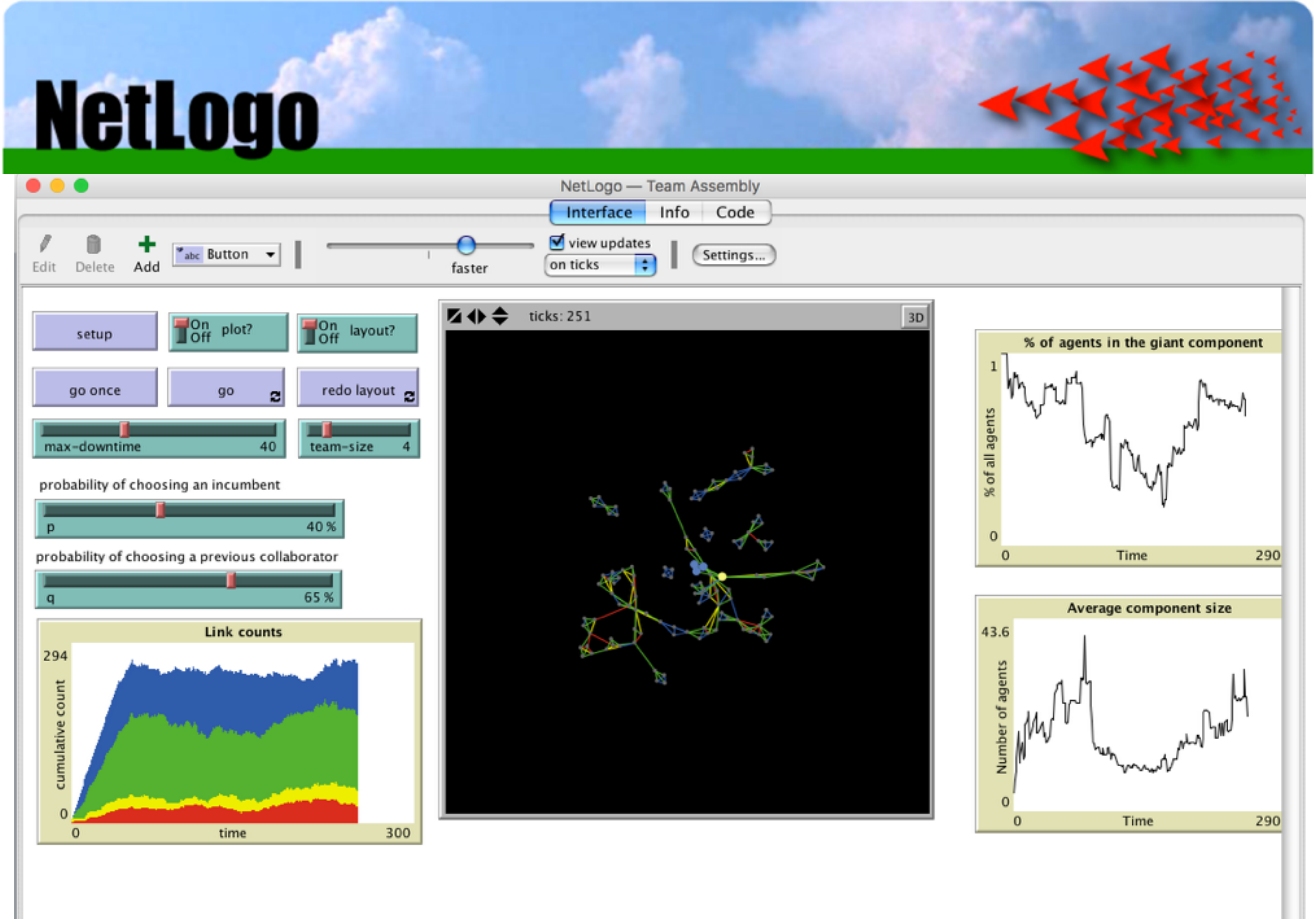


“Art is a lie that helps us see the truth.”

–Pablo Picasso

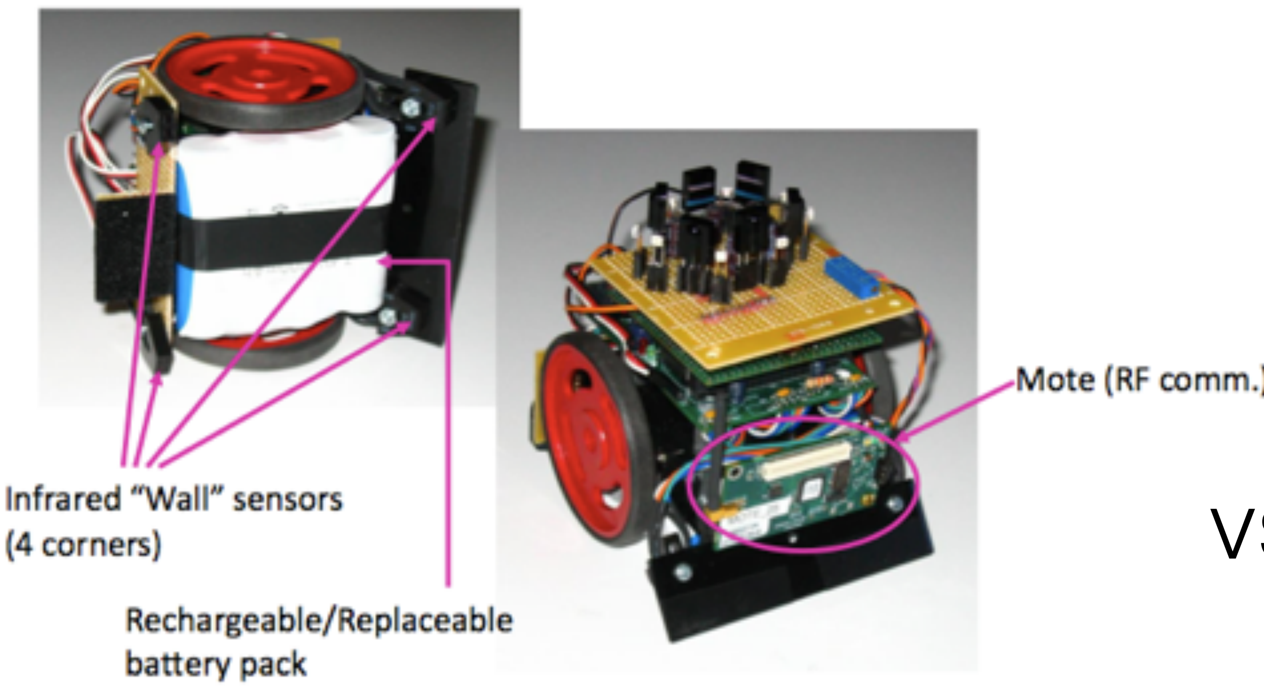
http://smaldino.com/wp/abm-course/

password: `cubistchicken`

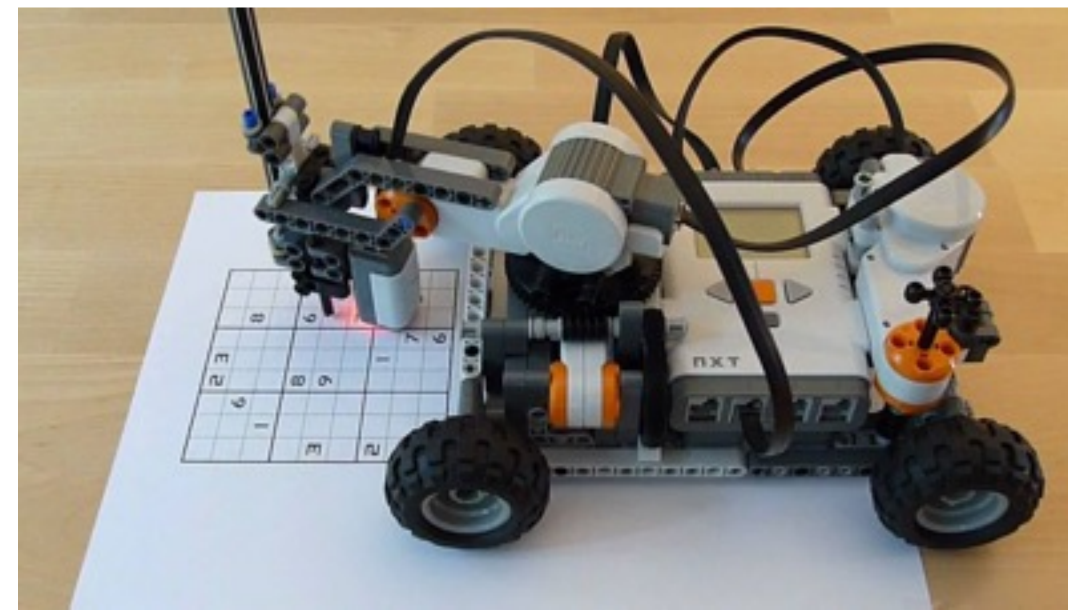


https://ccl.northwestern.edu/netlogo/

Levels of depth



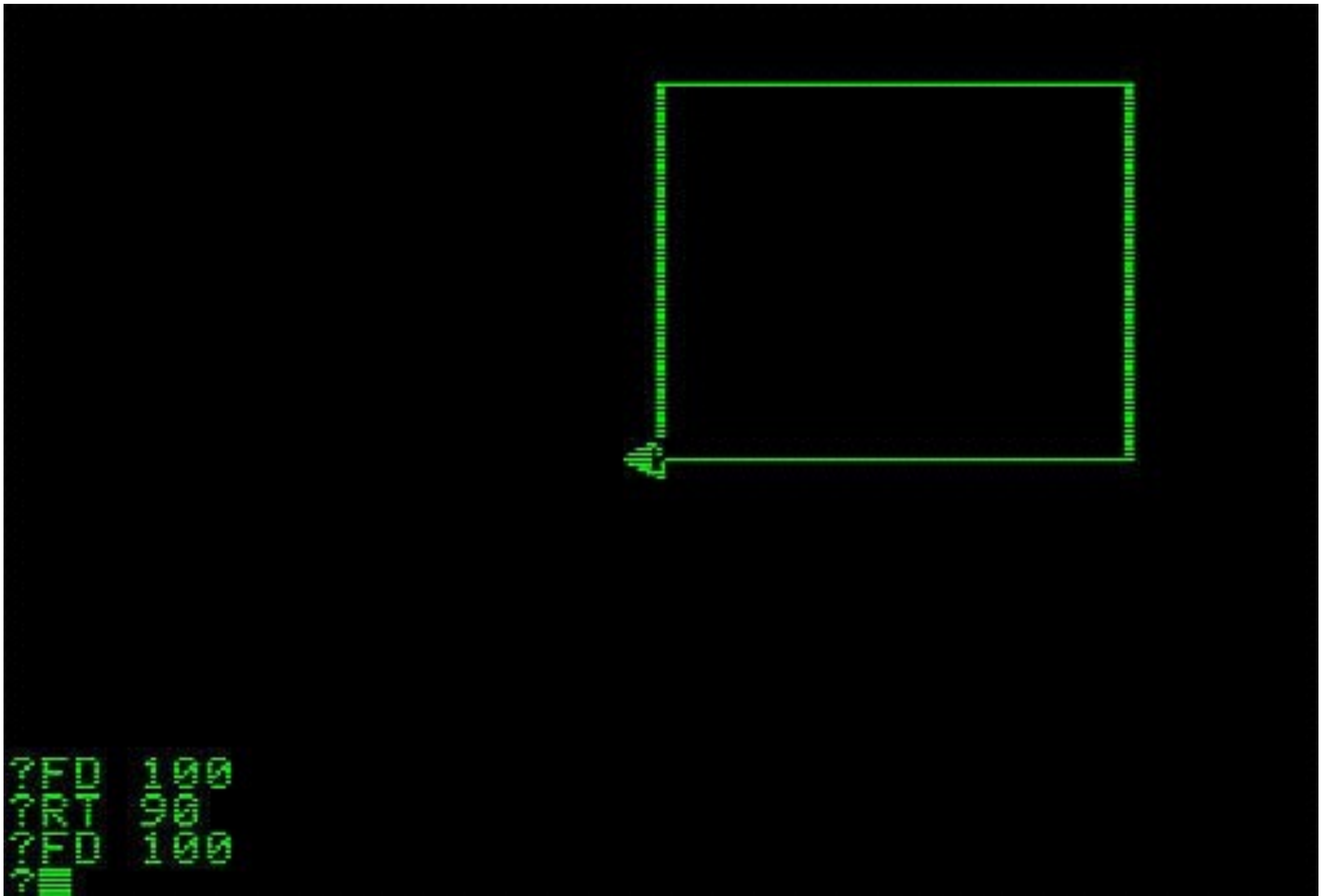
vs.



Java (MASON)
Python (Mesa)
C++
R
MatLab
Javascript

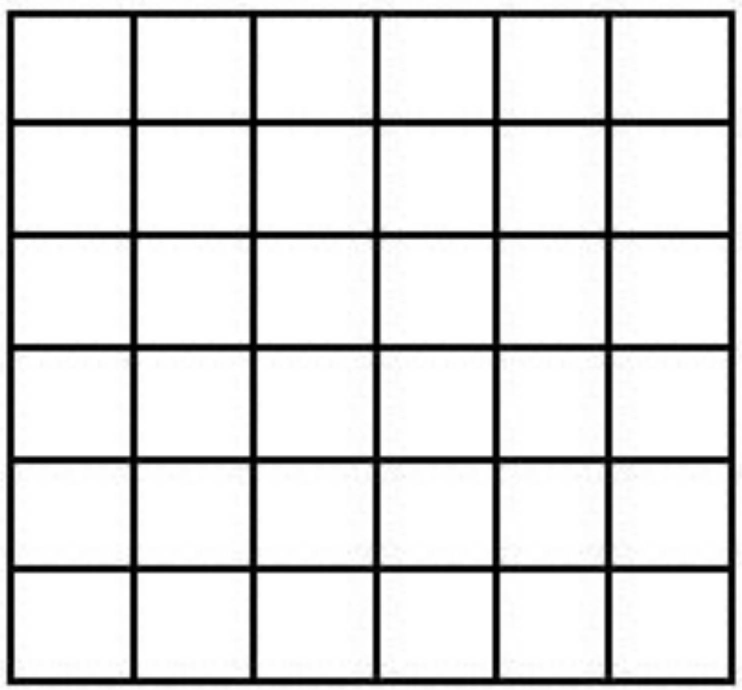
NetLogo

Logo Origins



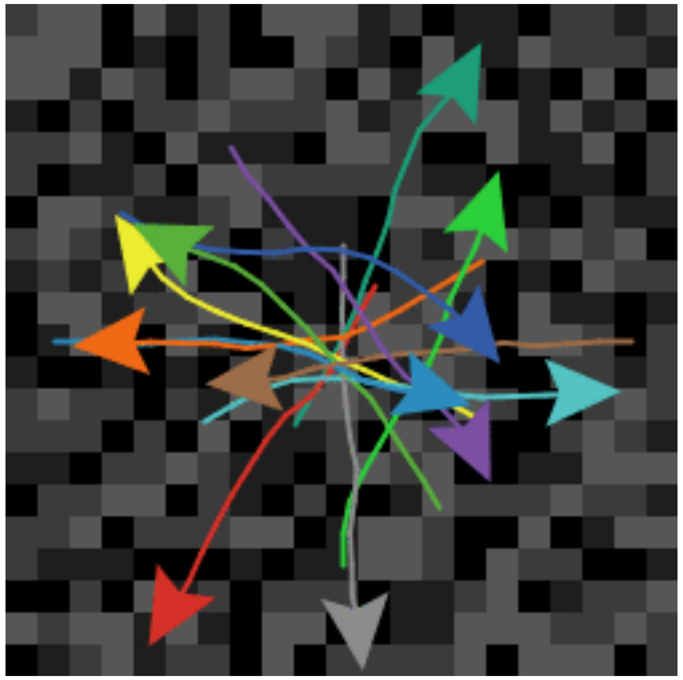
NetLogo Components

Patches



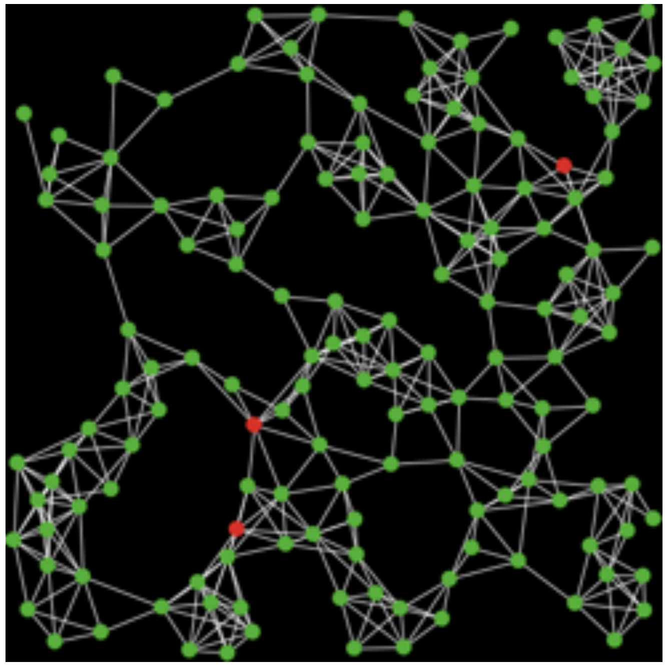
- stationary
- one per location

Turtles



- mobile
- can die and reproduce
- can be networked
- can occupy patches

Links

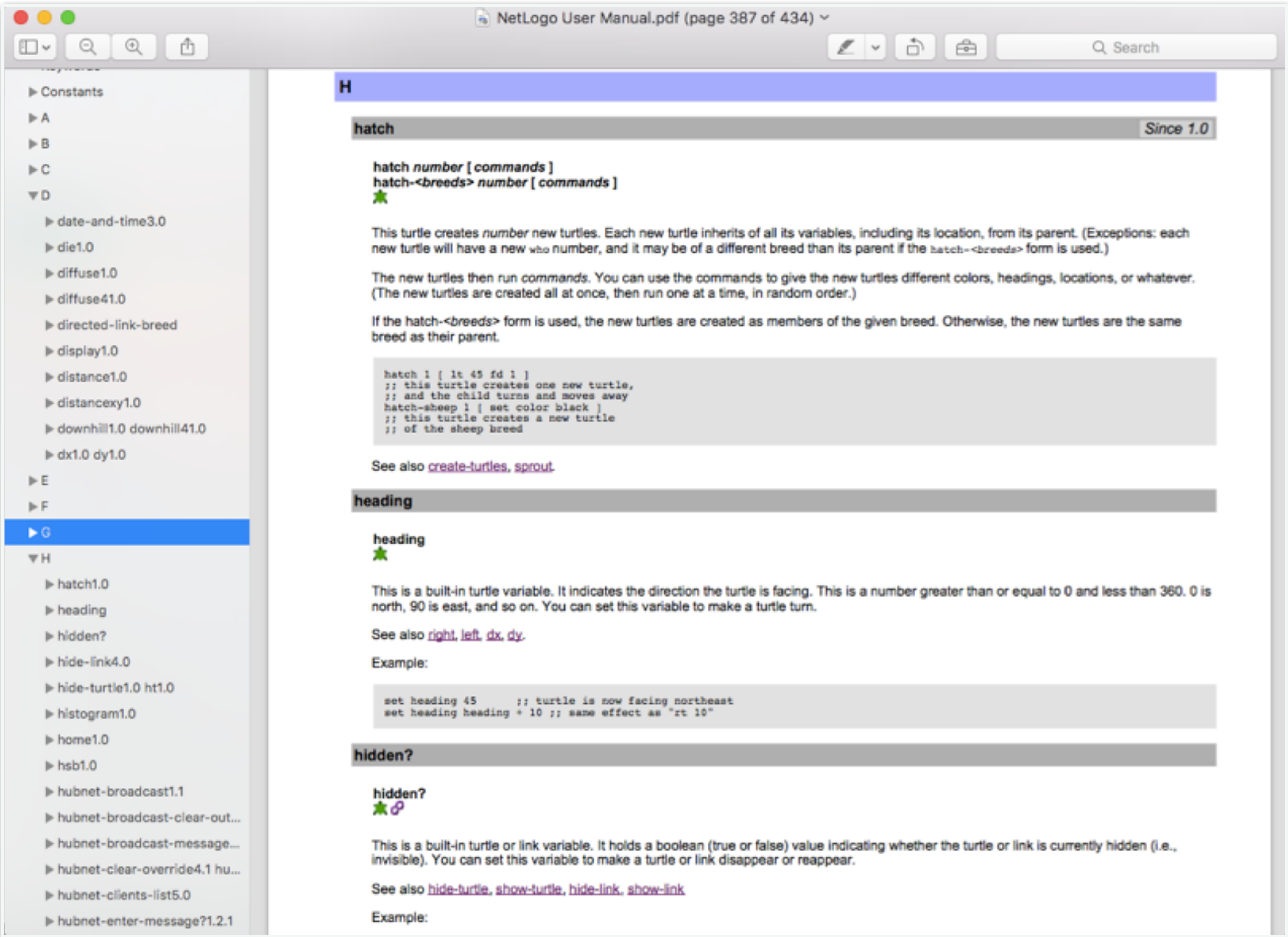


- connections between turtles
- can be directed or undirected

Agent-Oriented Programming

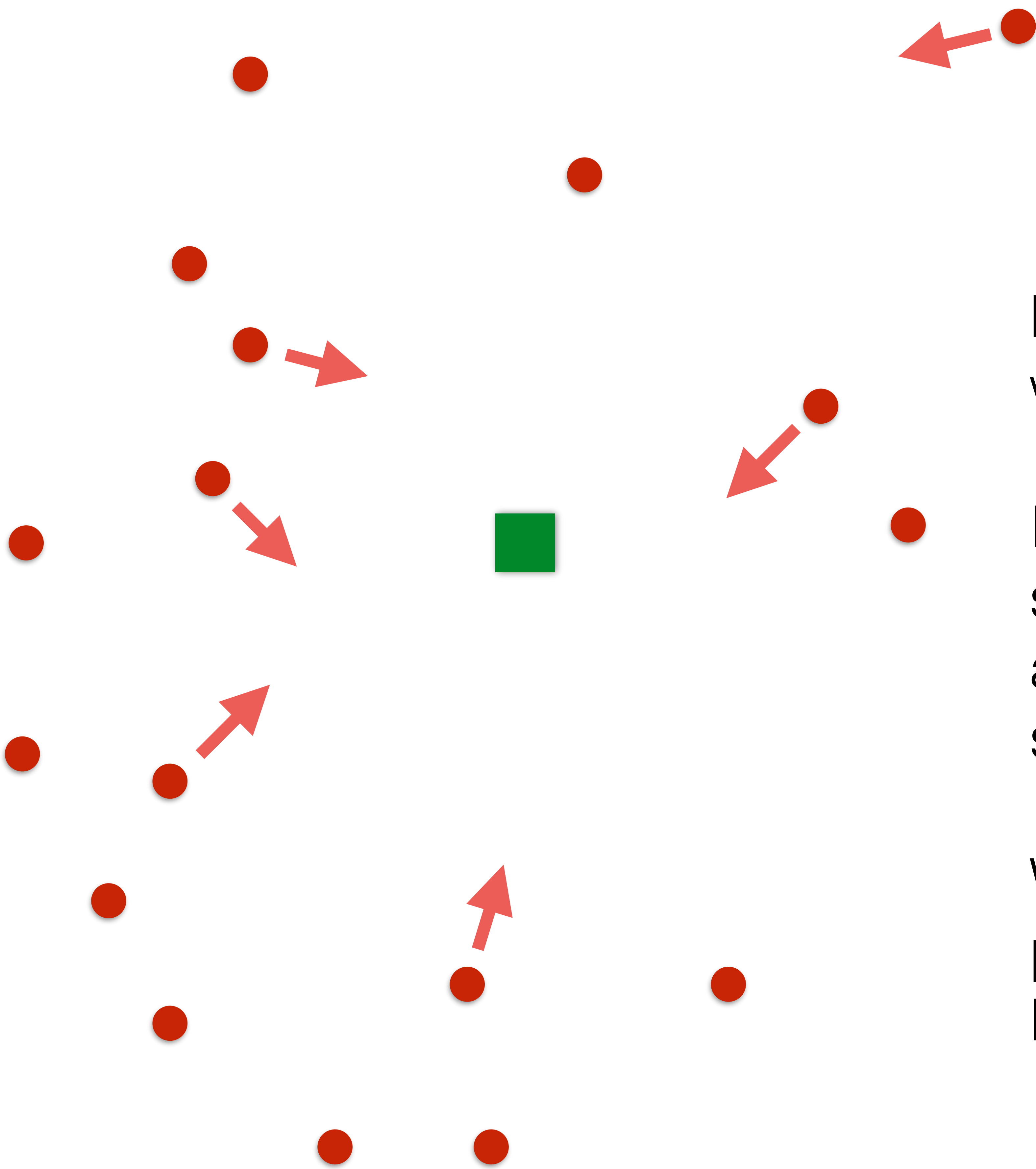
- NetLogo keeps track of the “level” at which a procedure is called.
- I.e., if a turtle calls a procedure, all commands are run from the turtle’s “perspective”
- NetLogo has many useful procedures and reporters that are ‘primitive’

The User’s Manual is your friend



Why model?

Can’t we just think it through?



Red particles do random walk through space.

If one touches a green square, it stops moving and becomes a green square.

What does resulting pattern of green squares look like?

VOLUME 47, NUMBER 19 PHYSICAL REVIEW LETTERS 9 NOVEMBER 1981

Diffusion-Limited Aggregation, a Kinetic Critical Phenomenon

T. A. Witten, Jr.[a]
Groupe de Physique de la Matière Condensée, Collège de France, F-75231 Paris, France

and

L. M. Sander
Physics Department, University of Michigan, Ann Arbor, Michigan 48109
(Received 31 August 1981)

A model for random aggregates is studied by computer simulation. The model is applicable to a metal-particle aggregation process whose correlations have been measured previously. Density correlations within the model aggregates fall off with distance with a fractional power law, like those of the metal aggregates. The radius of gyration of the model aggregates has power-law behavior. The model is a limit of a model of dendritic growth.

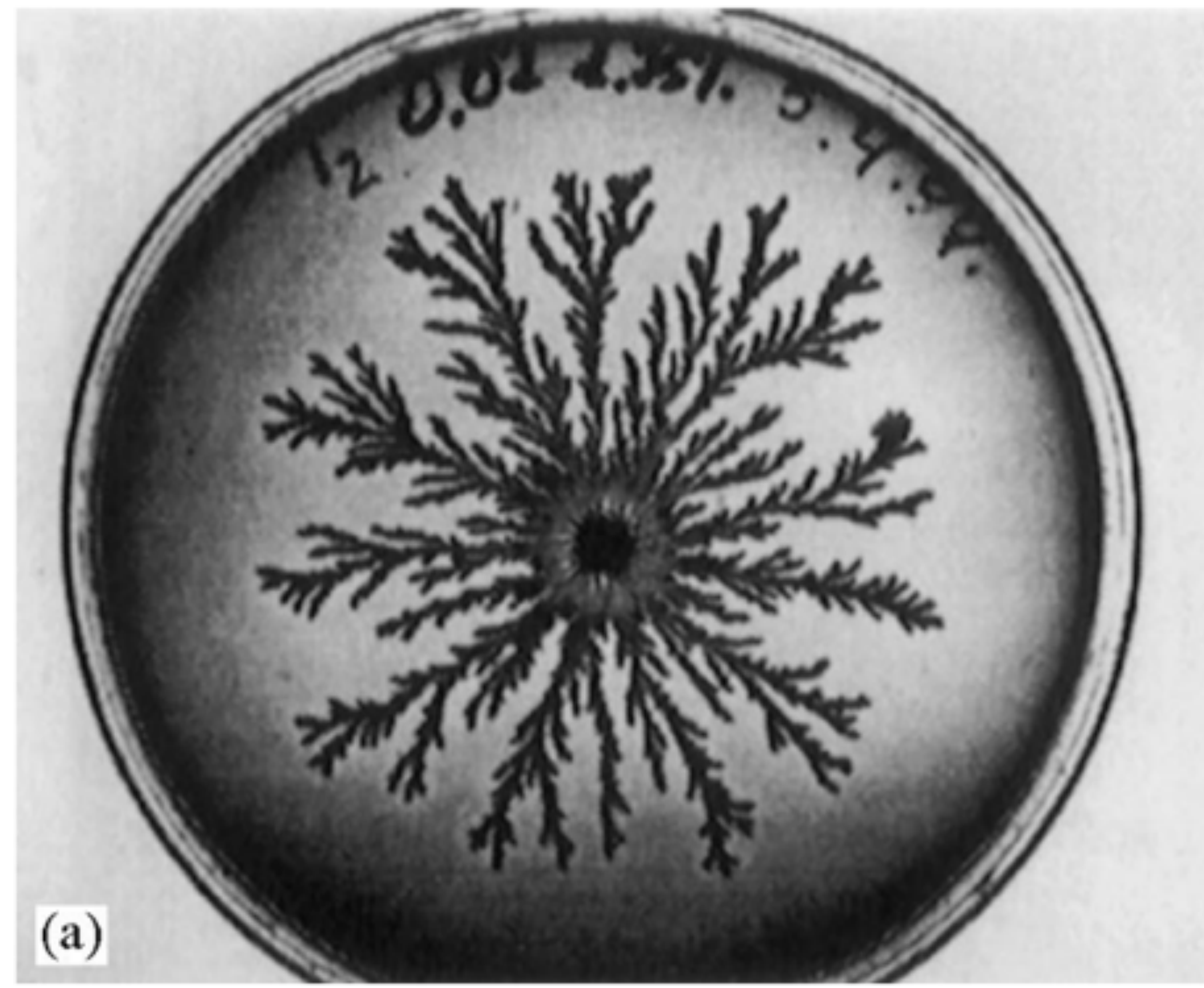
PACS numbers: 68.70.+w, 05.70.Jk, 64.60.Cn, 82.70.Rr

Models Library -> Chemistry & Physics -> Diffusion Limited Aggregation -> DLA Simple

Diffusion Limited Aggregation (Witten & Sander 1981)

Manganese oxidation on sandstone

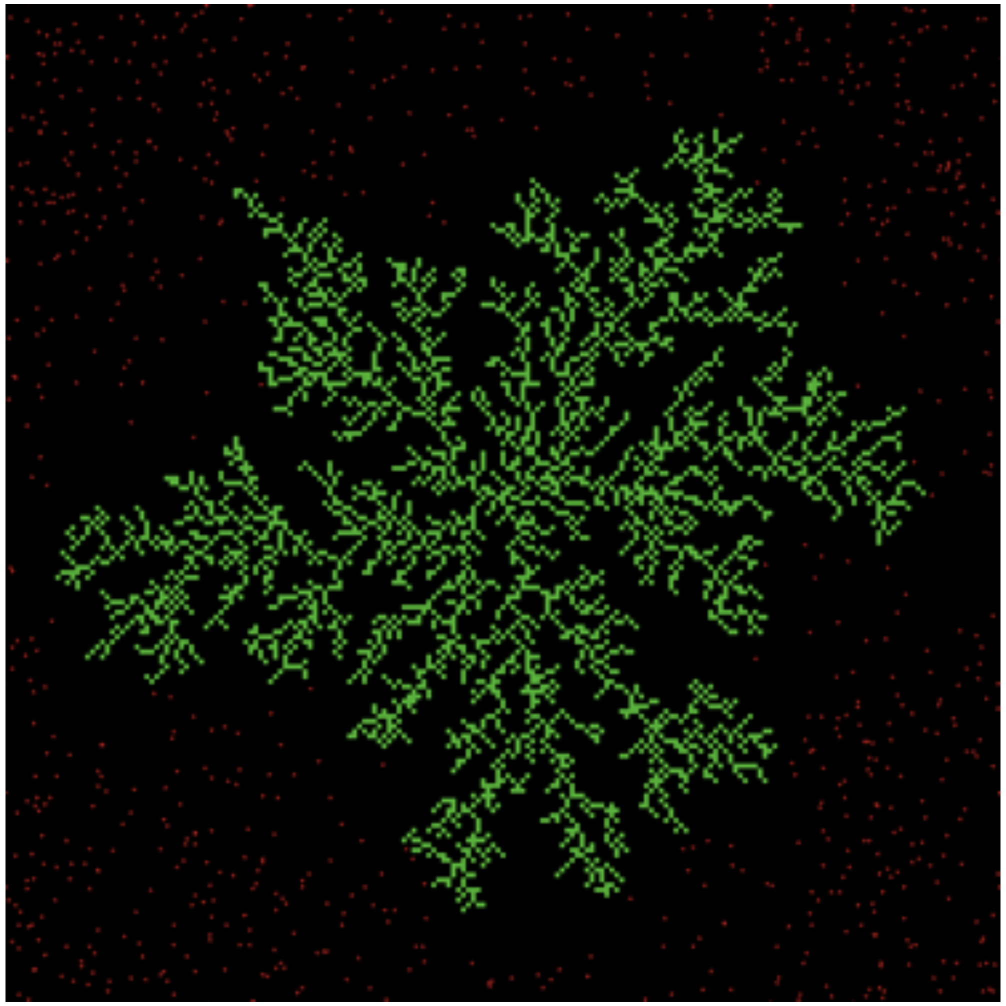
Bacterial growth in agar dish



Golding et al. (1998)

```
to setup
  clear-all
  ;; start with one green "seed" patch at the center of the world
  ask patch 0 0 [
    set pcolor green
  ]
  create-turtles num-particles [
    set color red
    set size 1.5 ;; easier to see
    setxy random-xcor random-ycor
  ]
  reset-ticks
end

to go
  ask turtles [
    ;; turn a random amount right and left
    right random wiggle-angle
    left random wiggle-angle
    forward 1
    ;; if you are touching a green patch
    if any? neighbors with [ pcolor = green ] [
      set pcolor green ;; turn your own patch green
      die ;; and then die
    ]
  ]
  tick
end
```

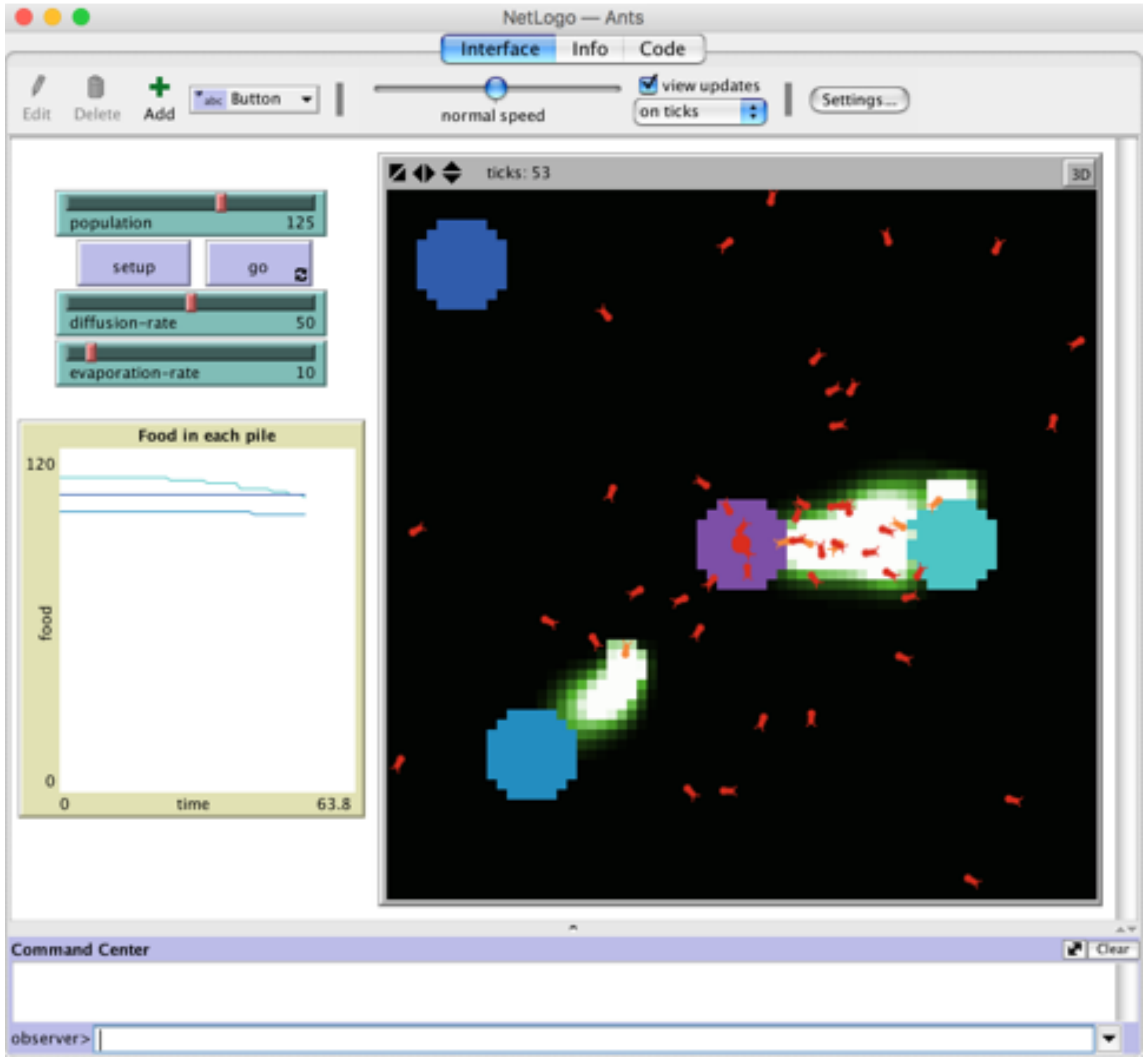


Ants Foraging

- Ants forage for food and form long coherent trails once a food source is located.

- In the 1970s, it was observed that ants deposit chemicals (pheromones) when returning to the nest with food, which can be detected by other ants. Is this the key?

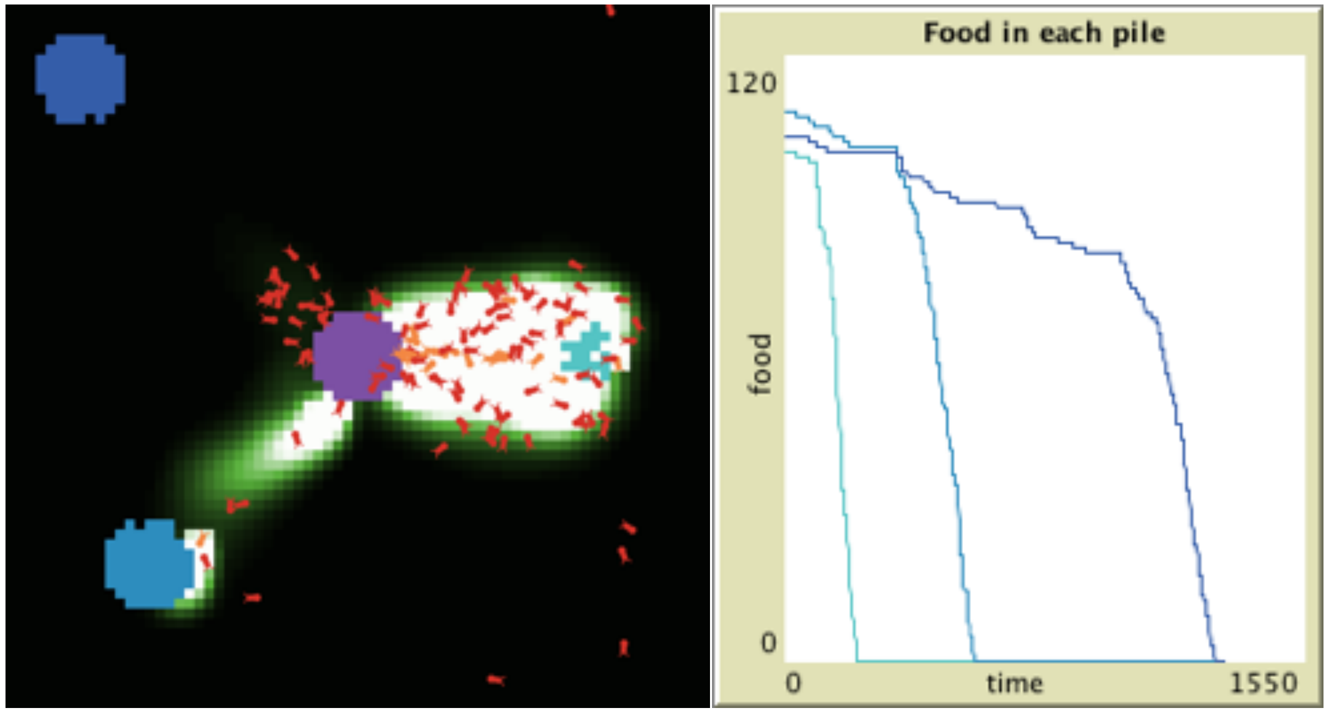
- Ants emerge from a nest and forage randomly until they encounter a food source.
- They emit a pheromone when returning to the nest with food. This pheromone both diffuses and evaporates.
- Does this help other ants find food?
- How does diffusion and evaporation rates affect the efficiency of foraging?



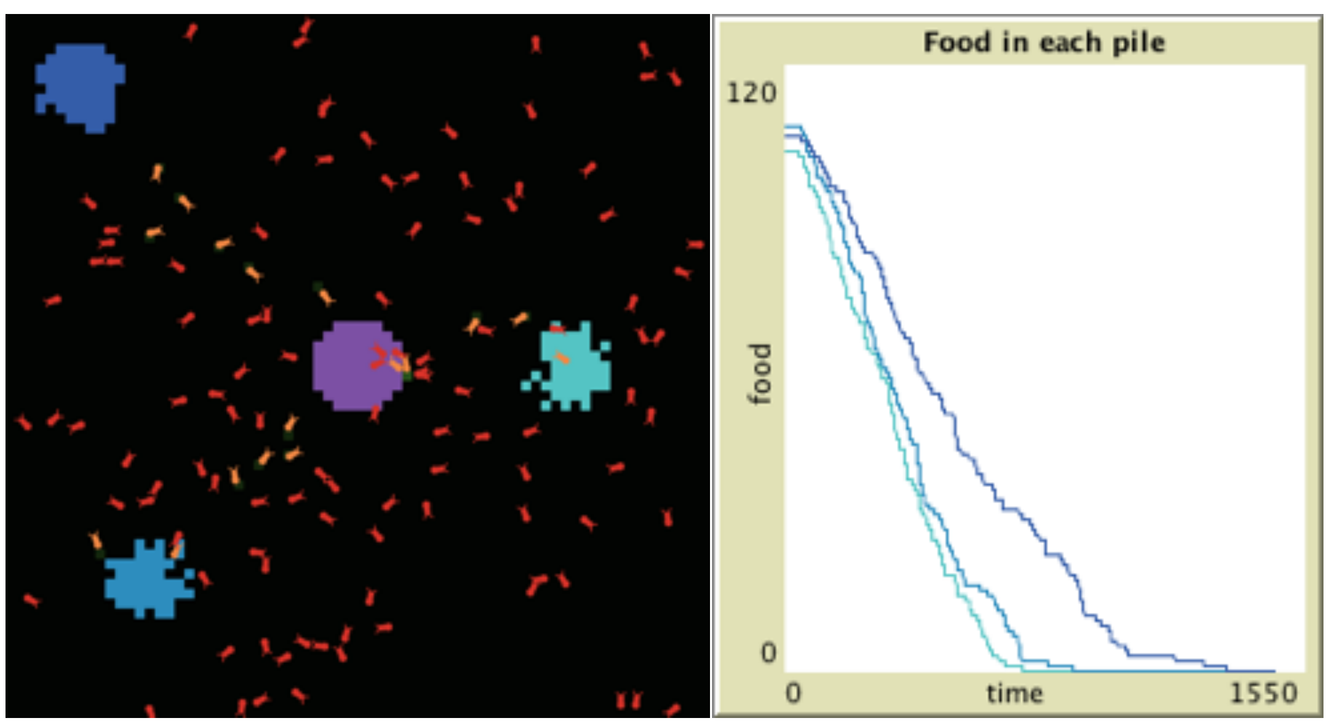
Sample models -> Biology -> Ants

71 x 71 grid

with pheromones

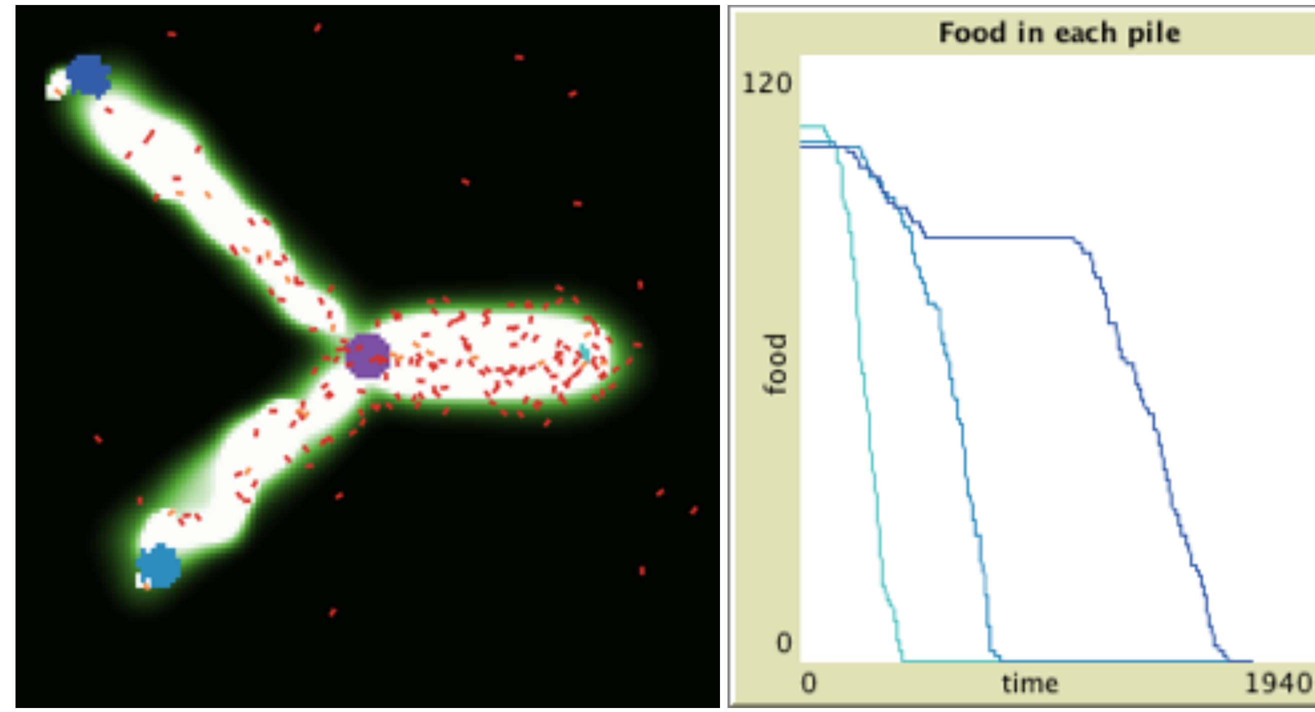


without pheromones

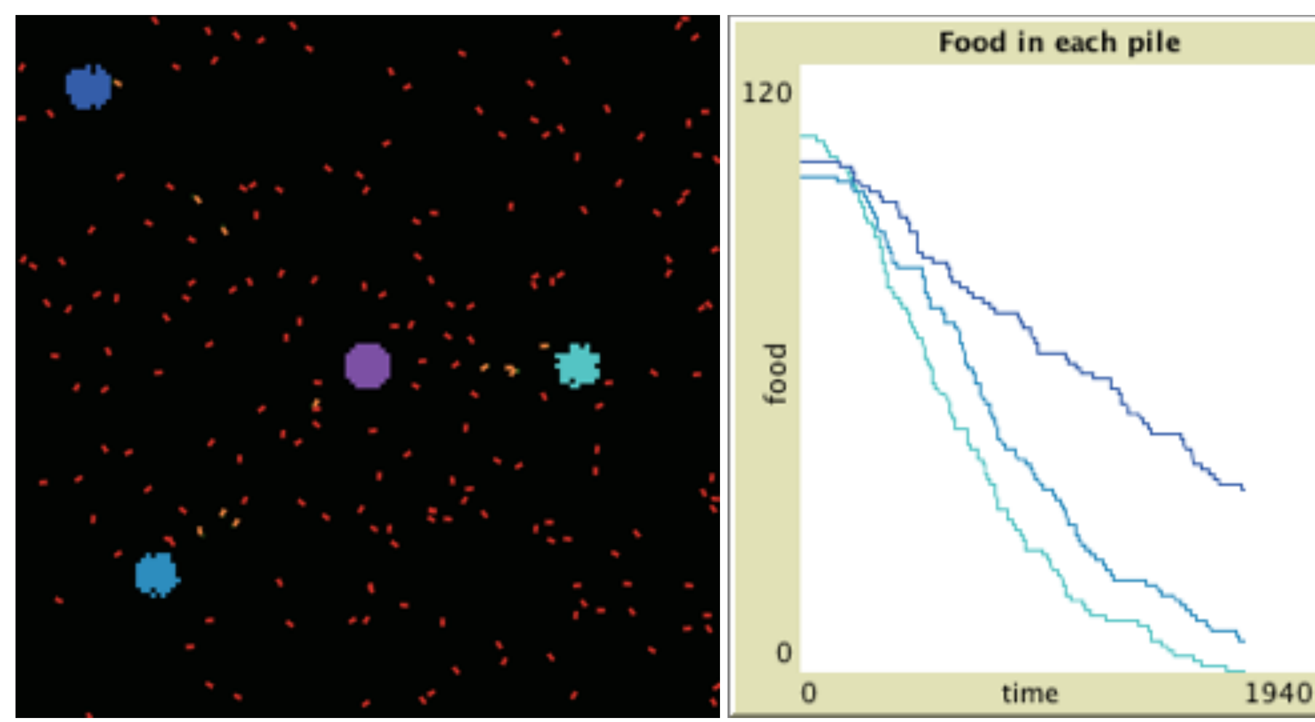


141 x 141 grid

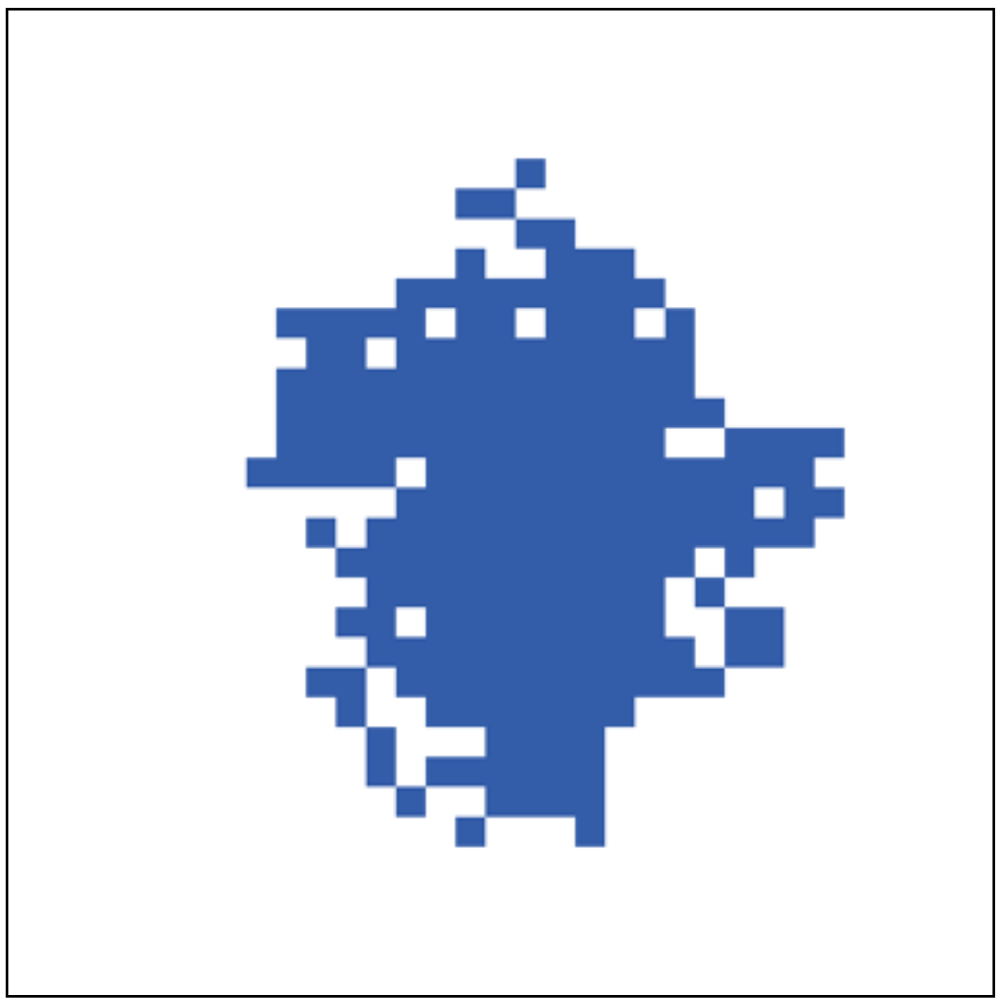
with pheromones

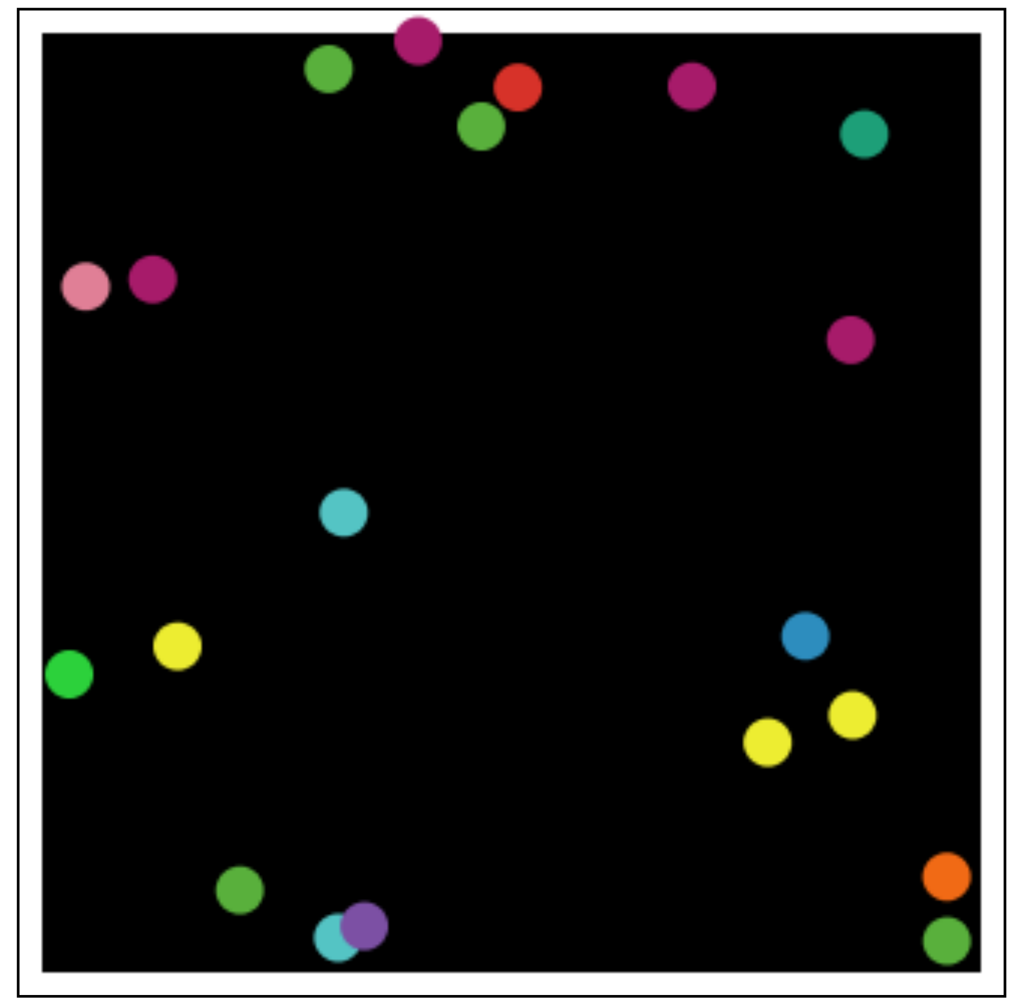


without pheromones



Modeling Challenges





- Remainder of today:
    - Attempt today’s Modeling Challenge
- Tomorrow:
    - Review of modeling challenge
    - Models of infection