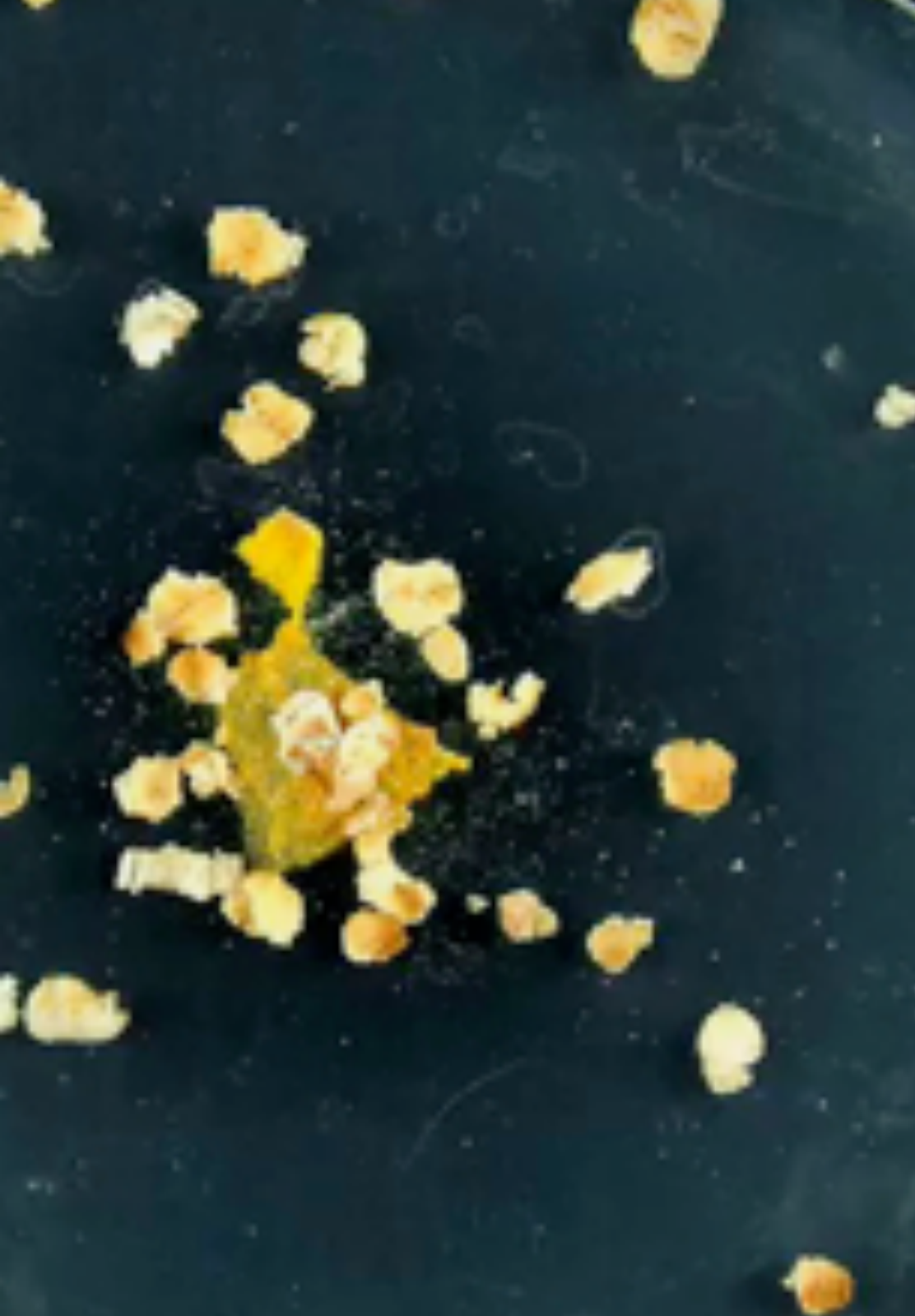


# Emergence

Karsten Droste  
[droste@arch.ethz.ch](mailto:droste@arch.ethz.ch)

# Knowing Emergence



This time lapse movie of the slime mold *Physarum polycephalum* represents 10 days of growth on an agar plate sprinkled with oatmeal flakes. Images were taken at 15 minute intervals.



Cornell University  
College of Agriculture  
and Life Sciences

"That I may detect the  
inmost force, which  
binds the world, and  
guides its course."

"Daß ich erkenne, was  
die Welt  
im Innersten  
zusammenhält."



Faust - Der Tragödie Erster Teil, Nacht  
Goethe, Johann Wolfgang von, 1749-1832

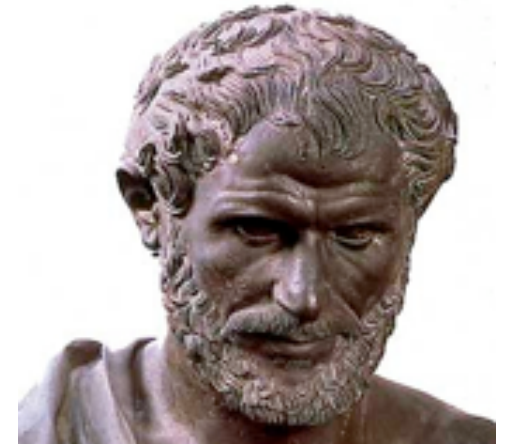
Emergence is the process of complex pattern formation from more basic constituent parts or behaviors, and manifests itself as an emergent property of the relationships between those elements.

- from wikipedia -

The whole is greater than the sum of the parts.

Das Ganze ist mehr als die Summe seiner Teile.

- Aristoteles 384BC-322BC



Who is in command?  
Who is the constructor?  
Is there a plan?





**Who is in command?  
Who is the constructor?  
Is there a plan?**





Who is in command?  
Who is the constructor?  
Is there a plan?



Who is in command?  
Who is the constructor?  
Is there a plan?

Who is in command?  
Who is the constructor?  
Is there a plan?





[Größeres Bild](#)

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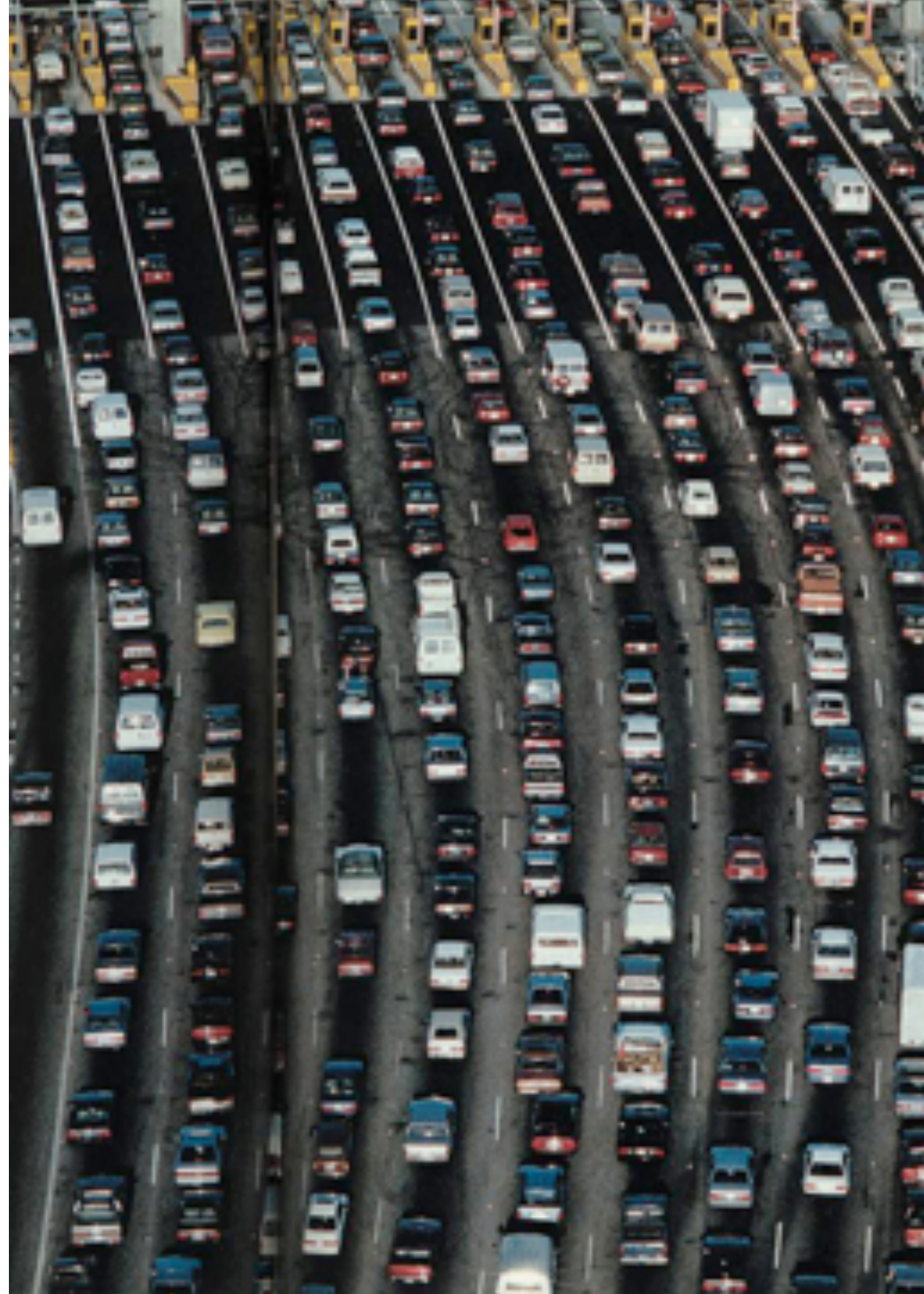
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Who is in command?  
Who is the constructor?  
Is there a plan?





1879



1929



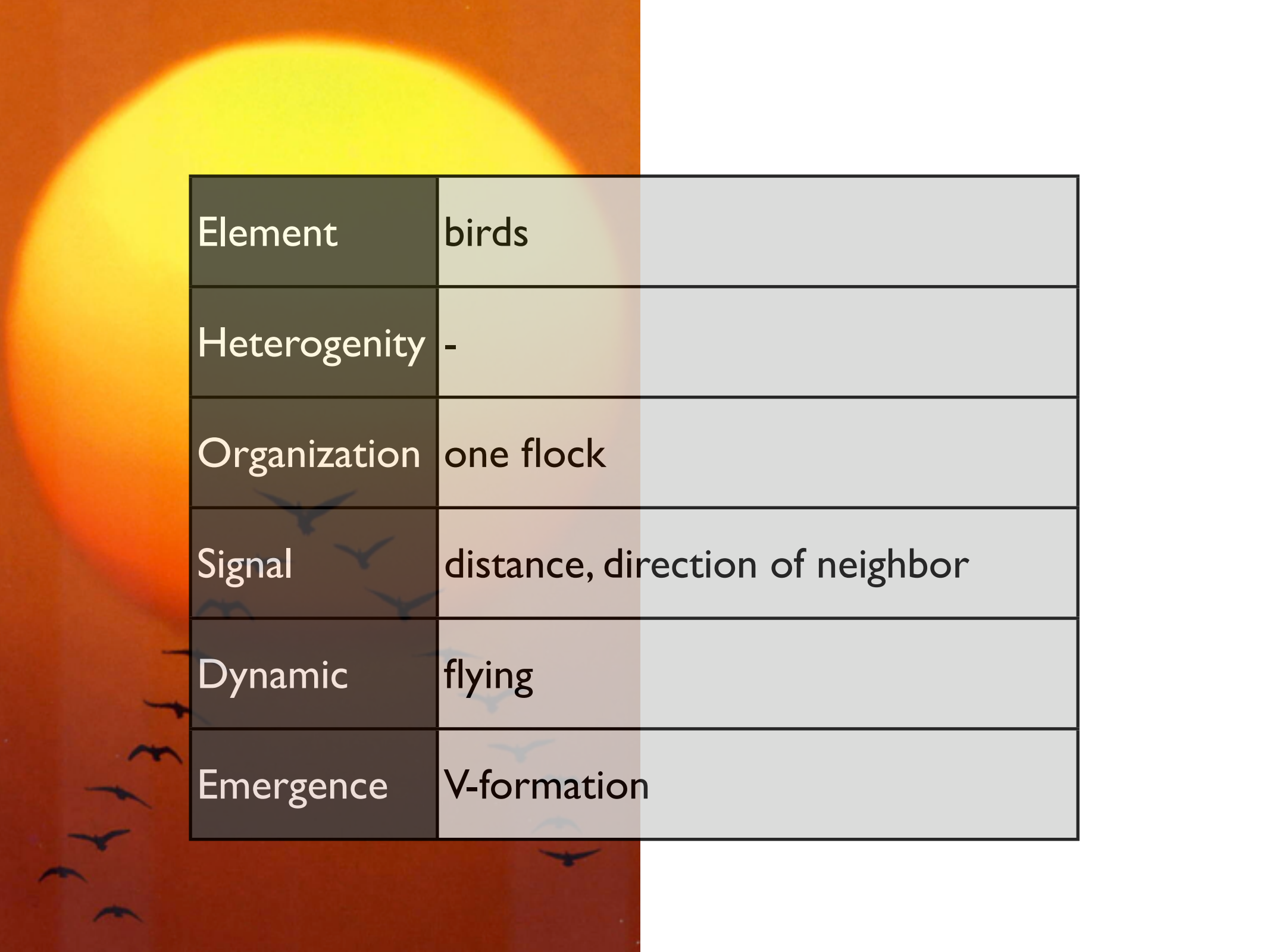
1987



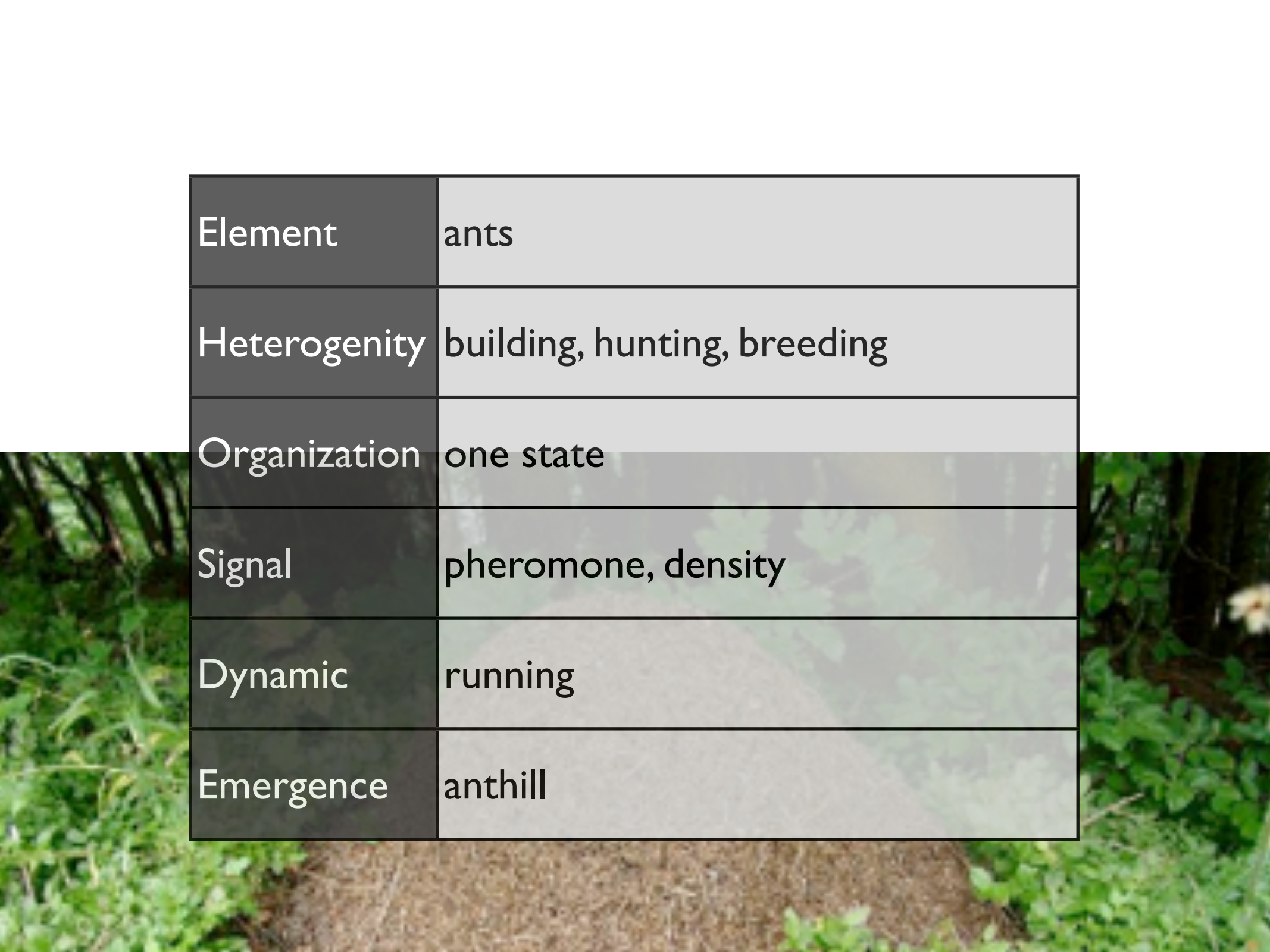
2001

# Identifying Emergence





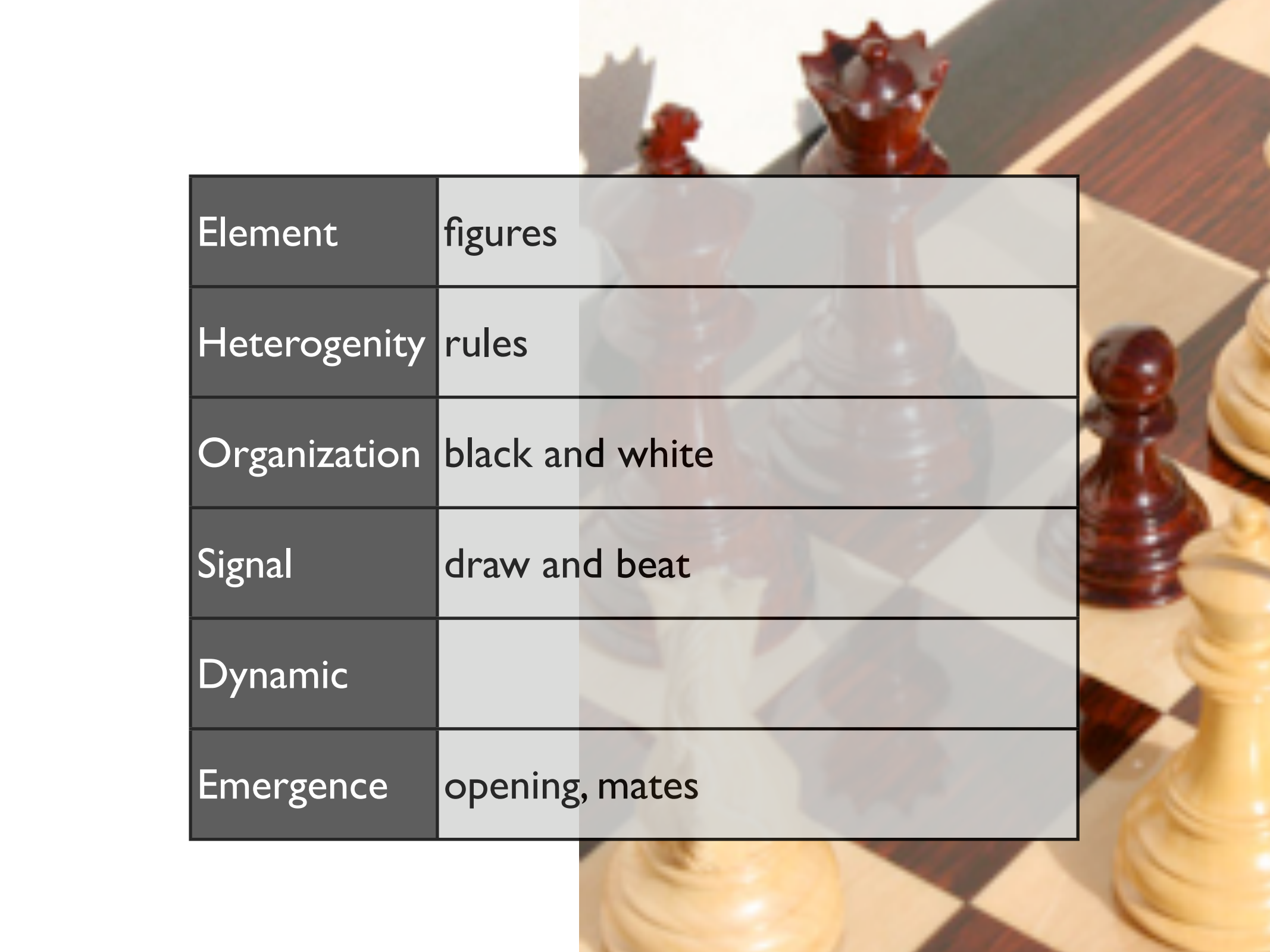
Element	birds	
Heterogeneity	-	
Organization	one flock	
Signal	distance, direction of neighbor	
Dynamic	flying	
Emergence	V-formation	



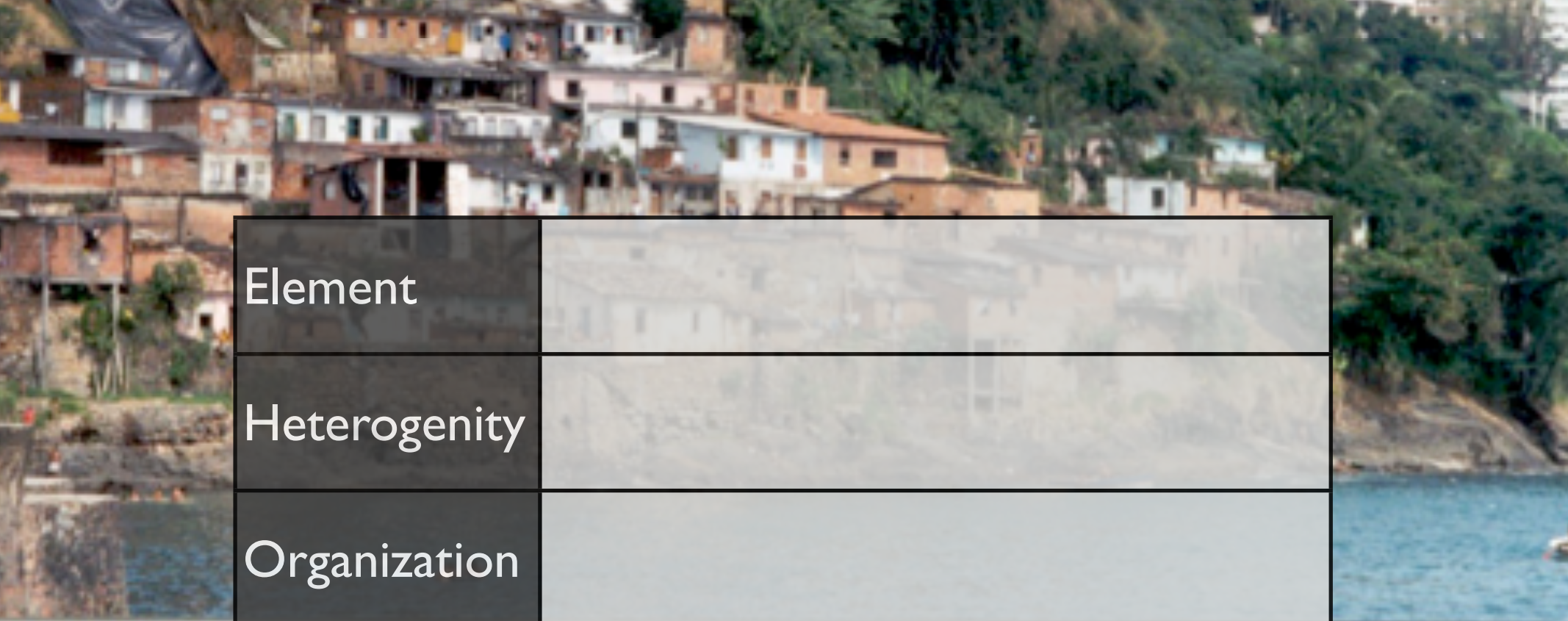
Element	ants
Heterogeneity	building, hunting, breeding
Organization	one state
Signal	pheromone, density
Dynamic	running
Emergence	anthill



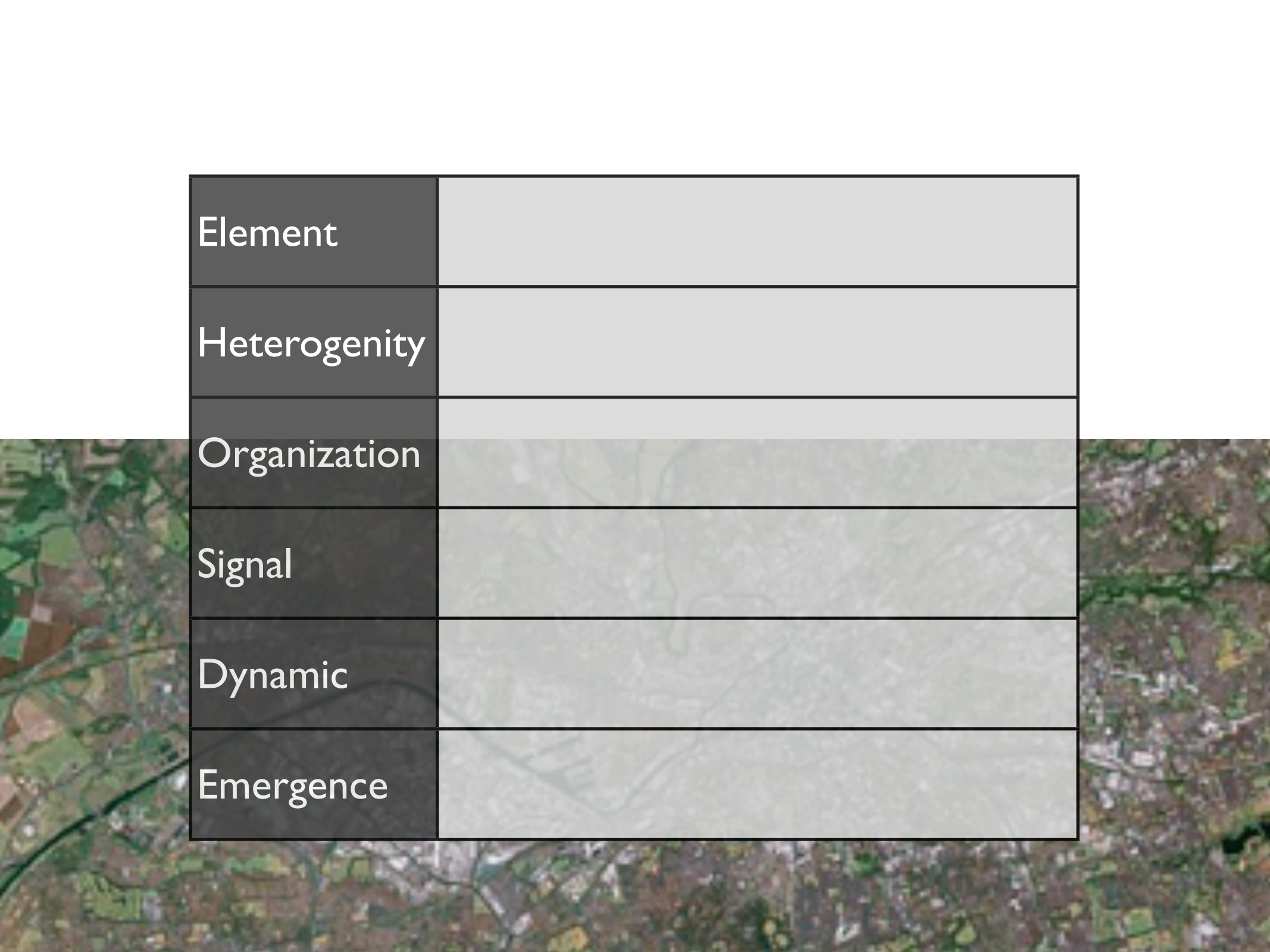
Element	cars	
Heterogeneity	speed, destination	
Organization	privat, buisness	
Signal	distances	
Dynamic	driving	
Emergence	traffic jam	



Element	figures
Heterogeneity	rules
Organization	black and white
Signal	draw and beat
Dynamic	
Emergence	opening, mates

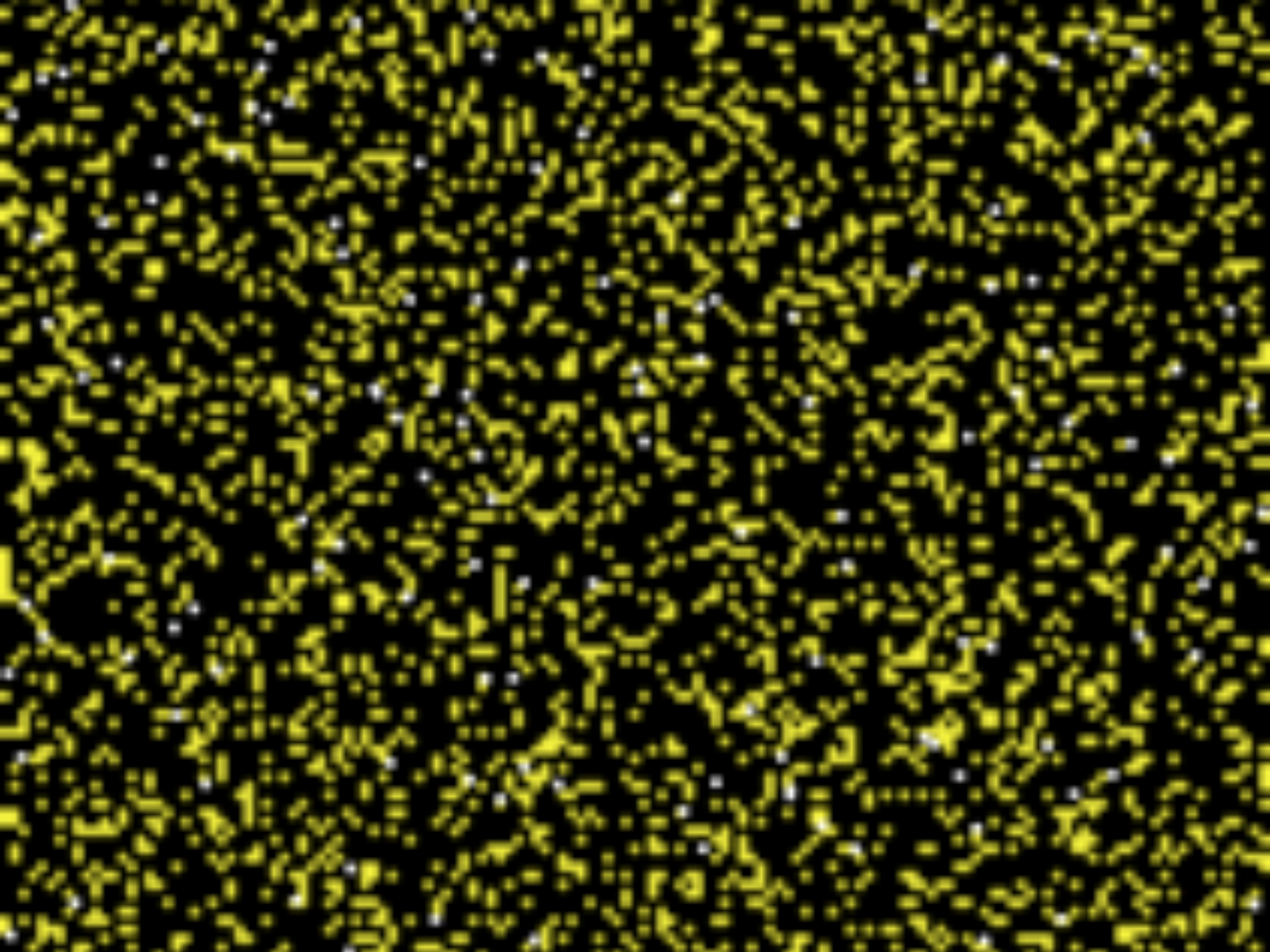


Element	
Heterogeneity	
Organization	
Signal	
Dynamic	
Emergence	

An aerial photograph of a landscape, possibly a rural or semi-rural area, showing fields, roads, and some buildings. A semi-transparent grid is overlaid on the image, with the left column of the grid containing text labels and the right column being empty. The grid is composed of six rows and two columns.

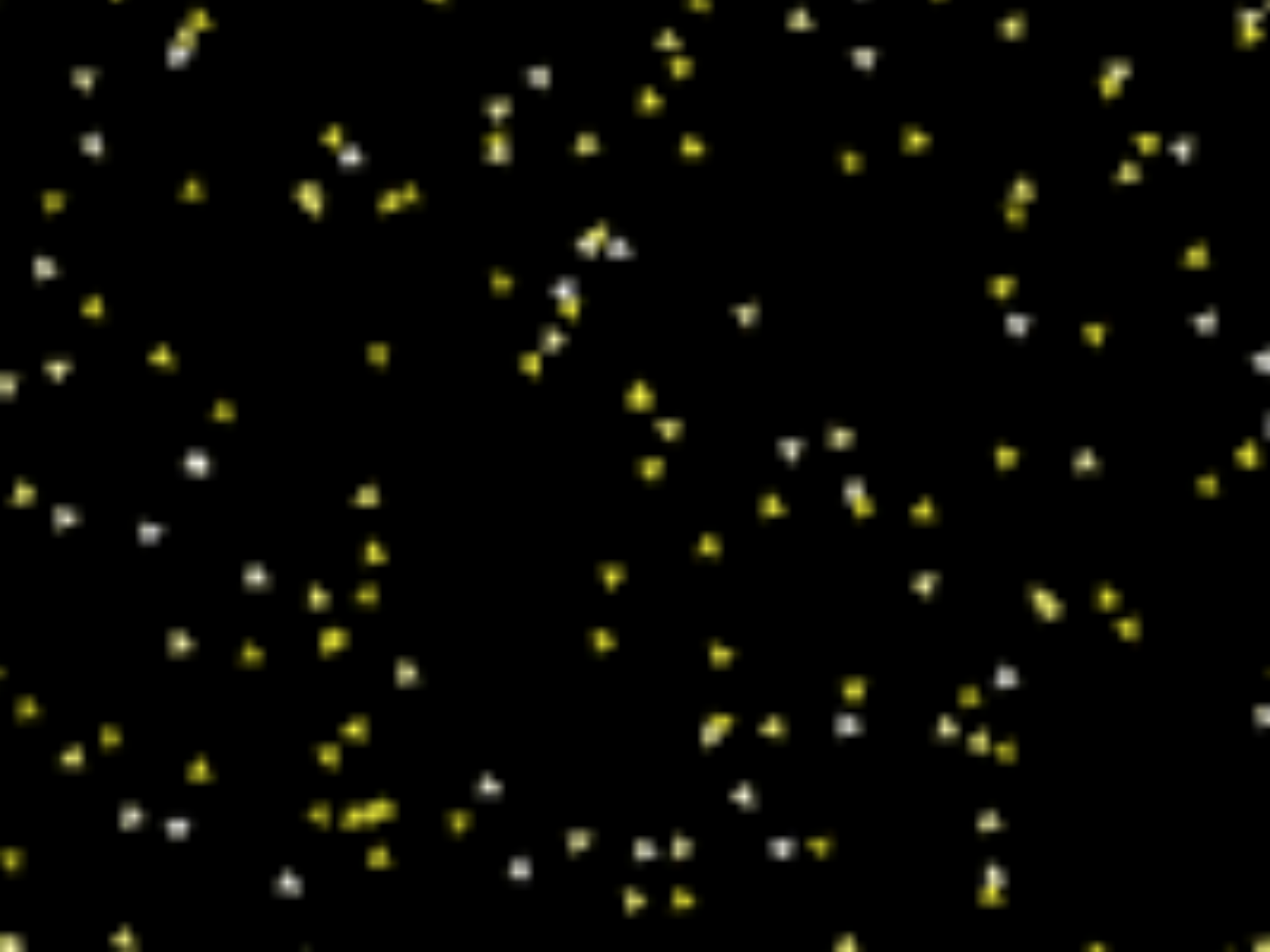
Element	
Heterogeneity	
Organization	
Signal	
Dynamic	
Emergence	

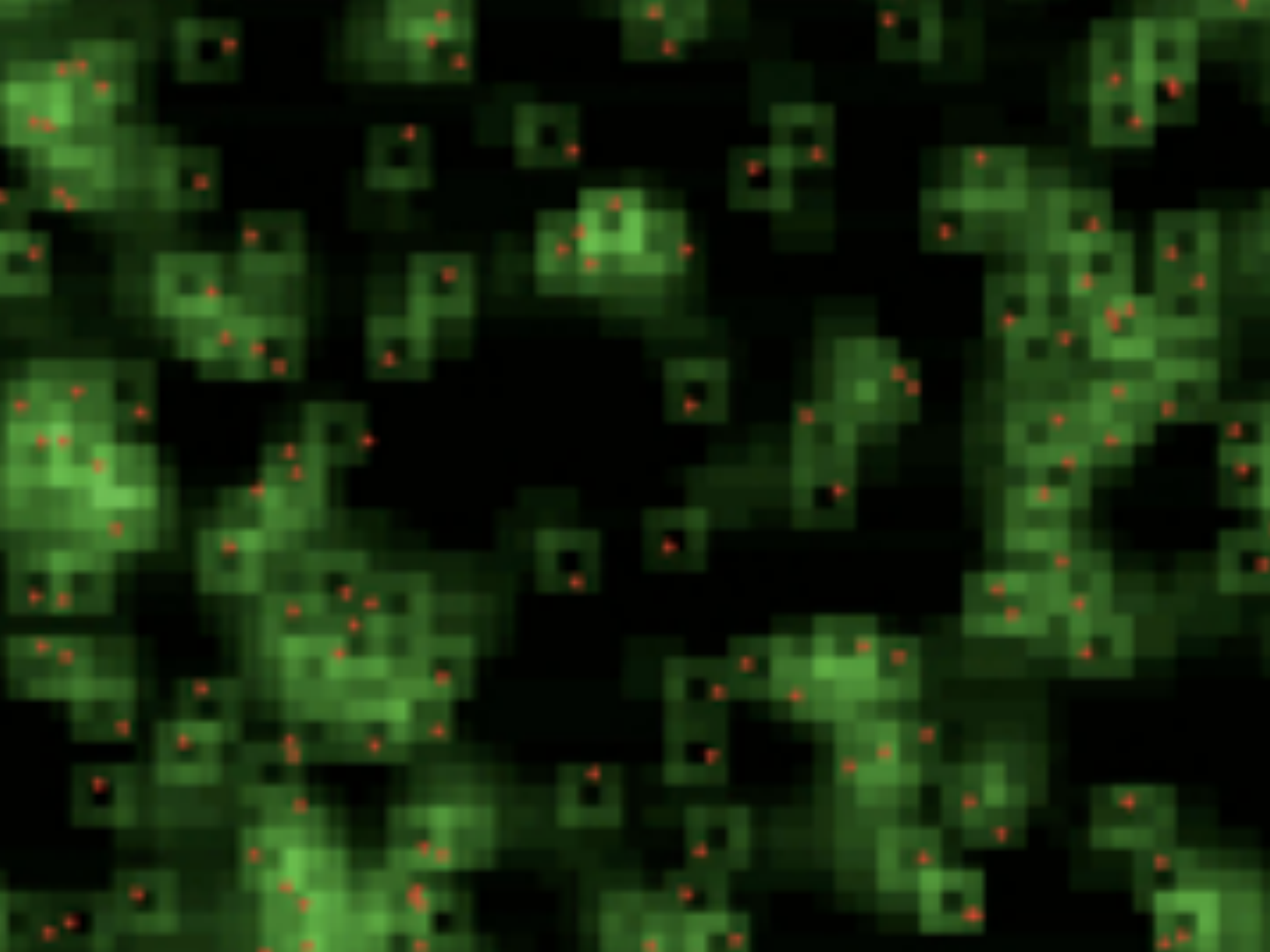
# Making of Emergence





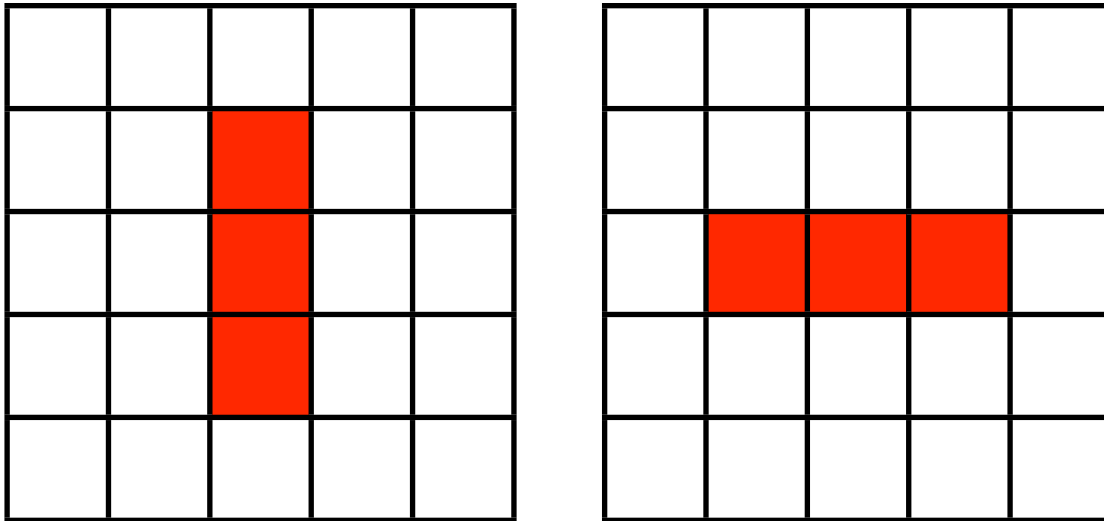








# Conway's Game Of Life

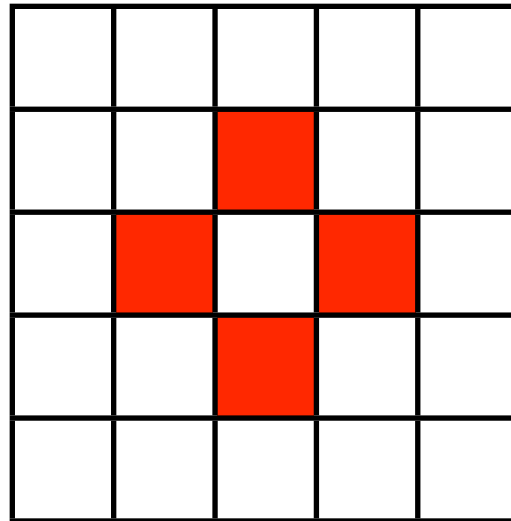
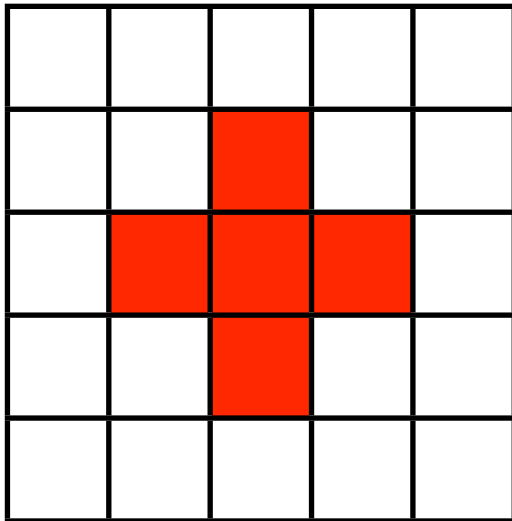


Given an infinite two-dimensional grid of cells.

- Any live cell with fewer than two neighbours dies.
- Any live cell with more than three neighbours dies.
- Any live cell with two or three neighbours lives.
- Any dead cell with exactly three neighbours comes to life.

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Glider  
Cannon



# Weaver's Three Camps of Science

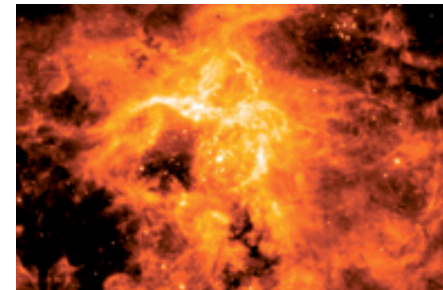
## Problems of Simplicity

17. 18. 19. Century  
a few variables



## Problems of Disorganised Complexity

since about 1900  
astronomical number of variables

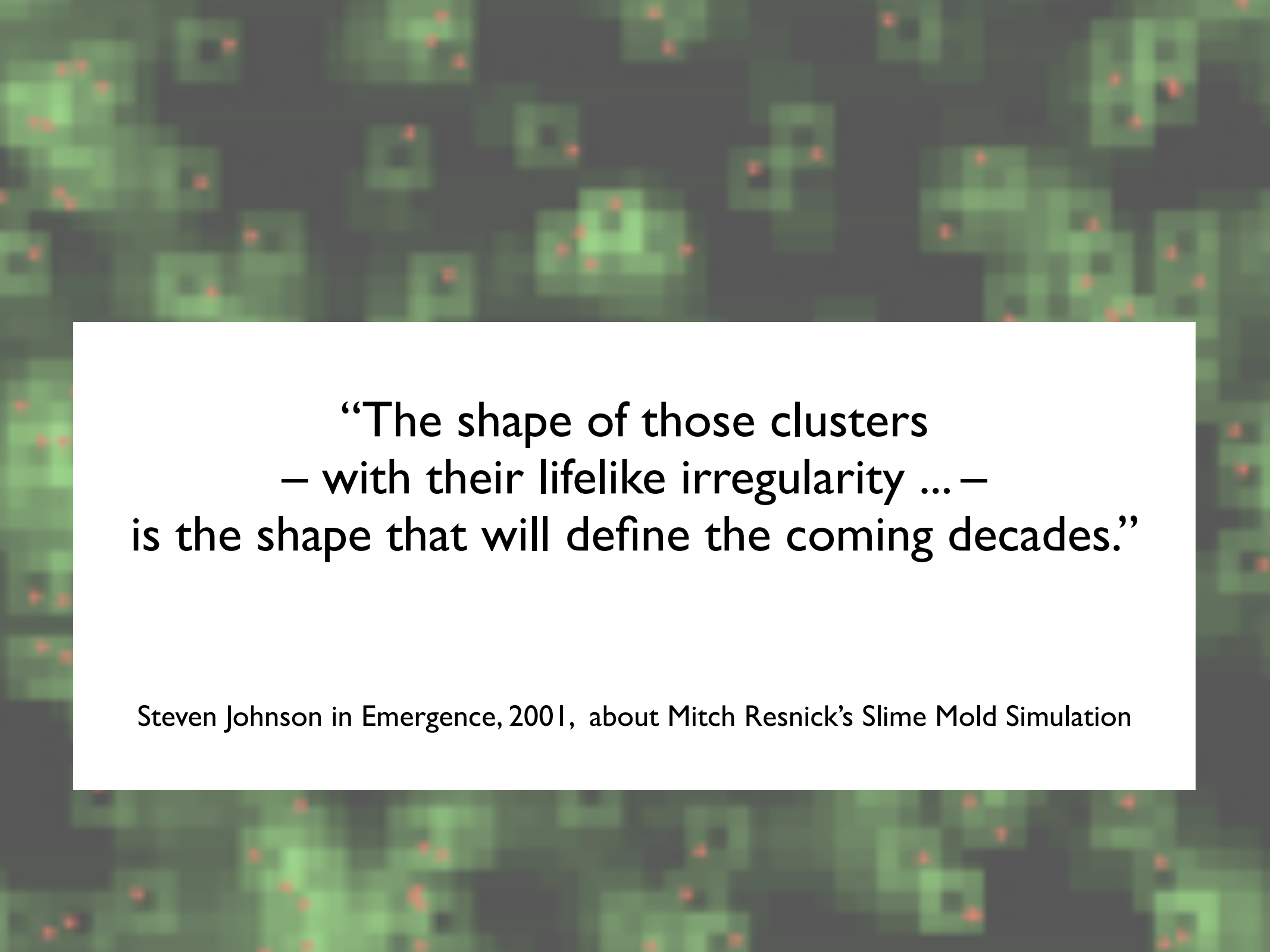


## Problems of Organised Complexity

since about 1950







“The shape of those clusters  
– with their lifelike irregularity ... –  
is the shape that will define the coming decades.”

Steven Johnson in *Emergence*, 2001, about Mitch Resnick’s Slime Mold Simulation

Self-Organizing Systems

Bottom Up Behaviour

Hierarchical Systems

Top Down Behaviour

You Tube

Internet Routing

Stock Market

Amazon

Conway's Game of Life

Ant Hill

Flocks

Wikipedia

TV Station

Powerplant

Mail Service

City Market

Schools