A Mutual Vocabulary

Cities and
Complex Adaptive Systems

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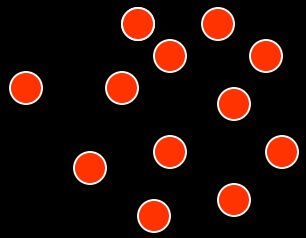
Organized complexity

Warren Weaver (1948)

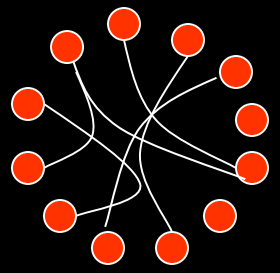
Problems of
Simplicity

Few Variables
(ex. mass, velocity)



Problems of
Disorganized Complexity

Billions of variables
Very little interactions
Statistical



Problems of
Organized Complexity

Many variables
Strong interactions
Interrelated in an organic whole

Cities happen to be problems in organized complexity, like the life sciences (…) The variables are many, but they are not helter-skelter; they are "interrelated into an organic whole."

Jane Jacobs, "The Death and Life of Great American Cities" (1961)

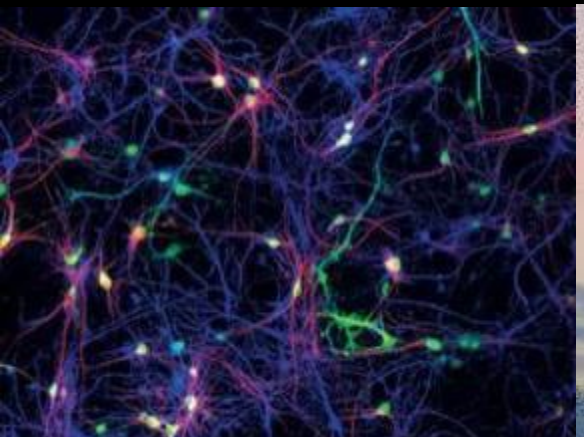
What does it tell us?

A world of Systems

Local interactions among a large number of components can lead to global forms of organization which are non-predictable from the observation of the parts alone

we are part of complex adaptive systems.

the brain



organisms

ecosystems

We produce a world of Systems

Local interactions among a large number of components can lead to non-predictable global consequences

Well functioning complex systems are essential to our collective survival:

Markets

the web

infrastructure networks

Historical Progression: Civilization becoming more complex

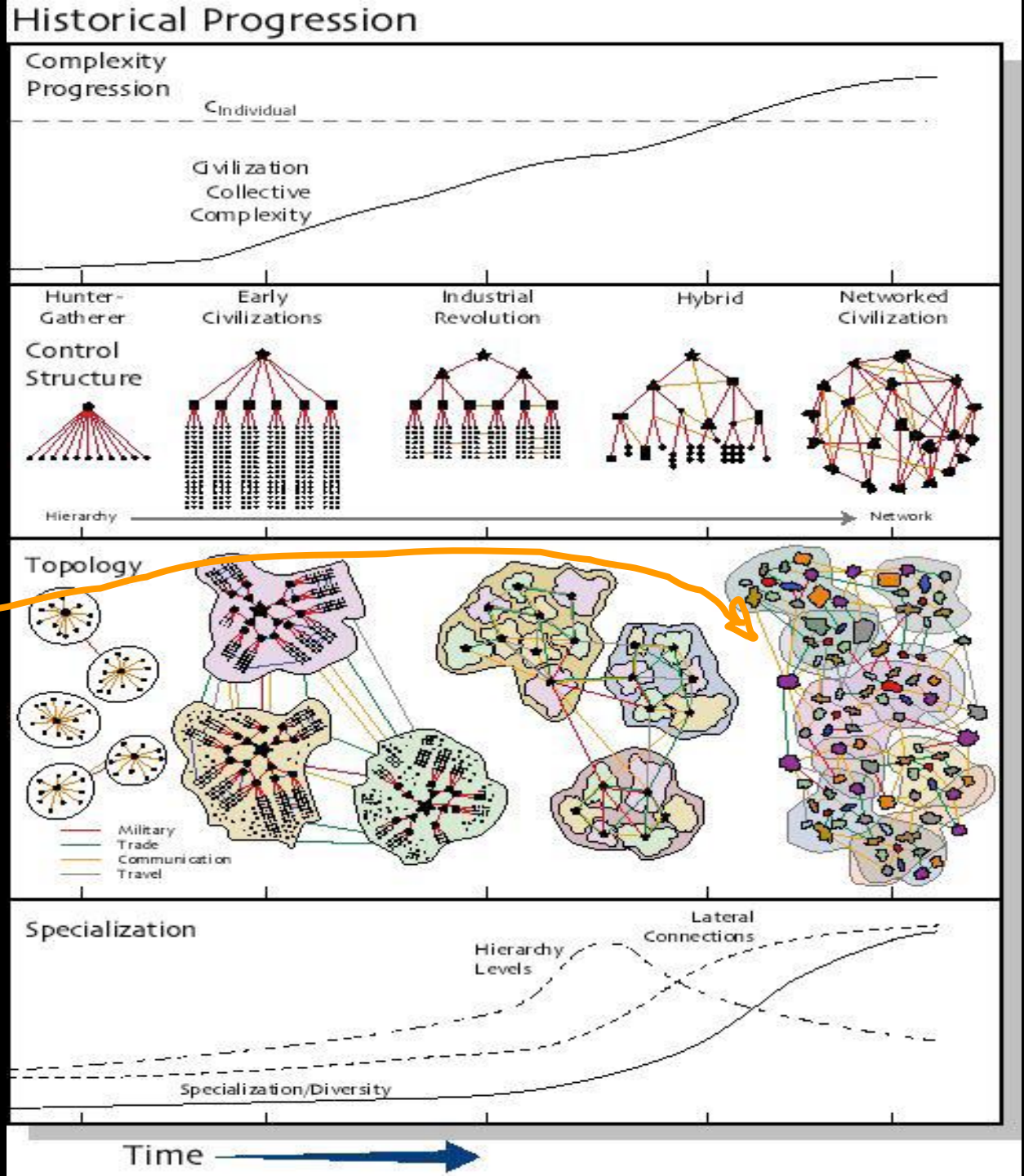
Multiple Scales

Multiple Layers

Multiple Languages

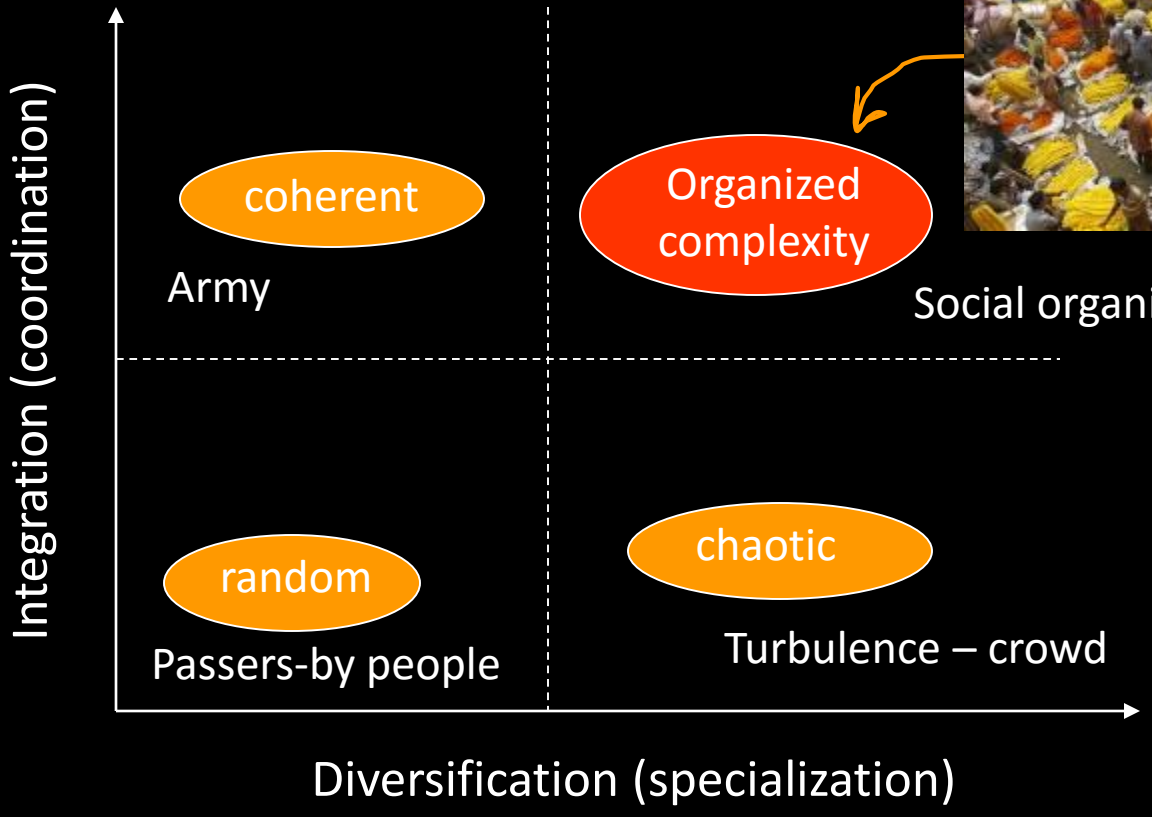
Enclosures

Y. Bar Yam (1997)



Diversification & Integration

Diversity, Connectivity, Interdependence



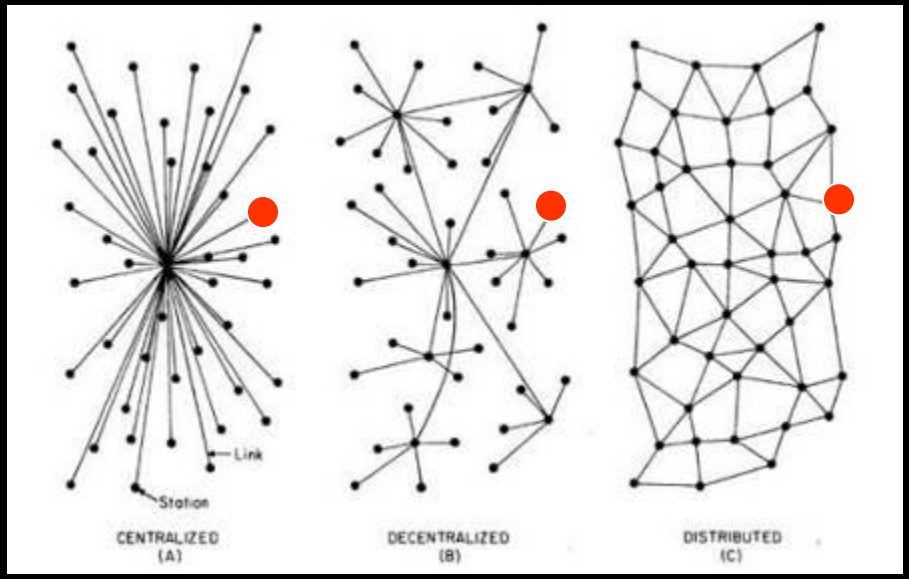
Organized Complexity is Adaptive

Highly complex collective behaviors are capable of responding to changing conditions, by influencing their structure and behavior at multiple scales. And they do learn – they retain information from past experience/memory.

Looking through Complexity allows to bridge the gap

between the individual and the collective:

from bottom-up local actions to global emerging patterns that in turn are influencing the system top-down



3 Examples…

Where collective coordination leads to collective intelligent behavior, by solving problems that exceed the knowledge of the individual, thus extracting value from the overall collective capacity.

Collective Coordination

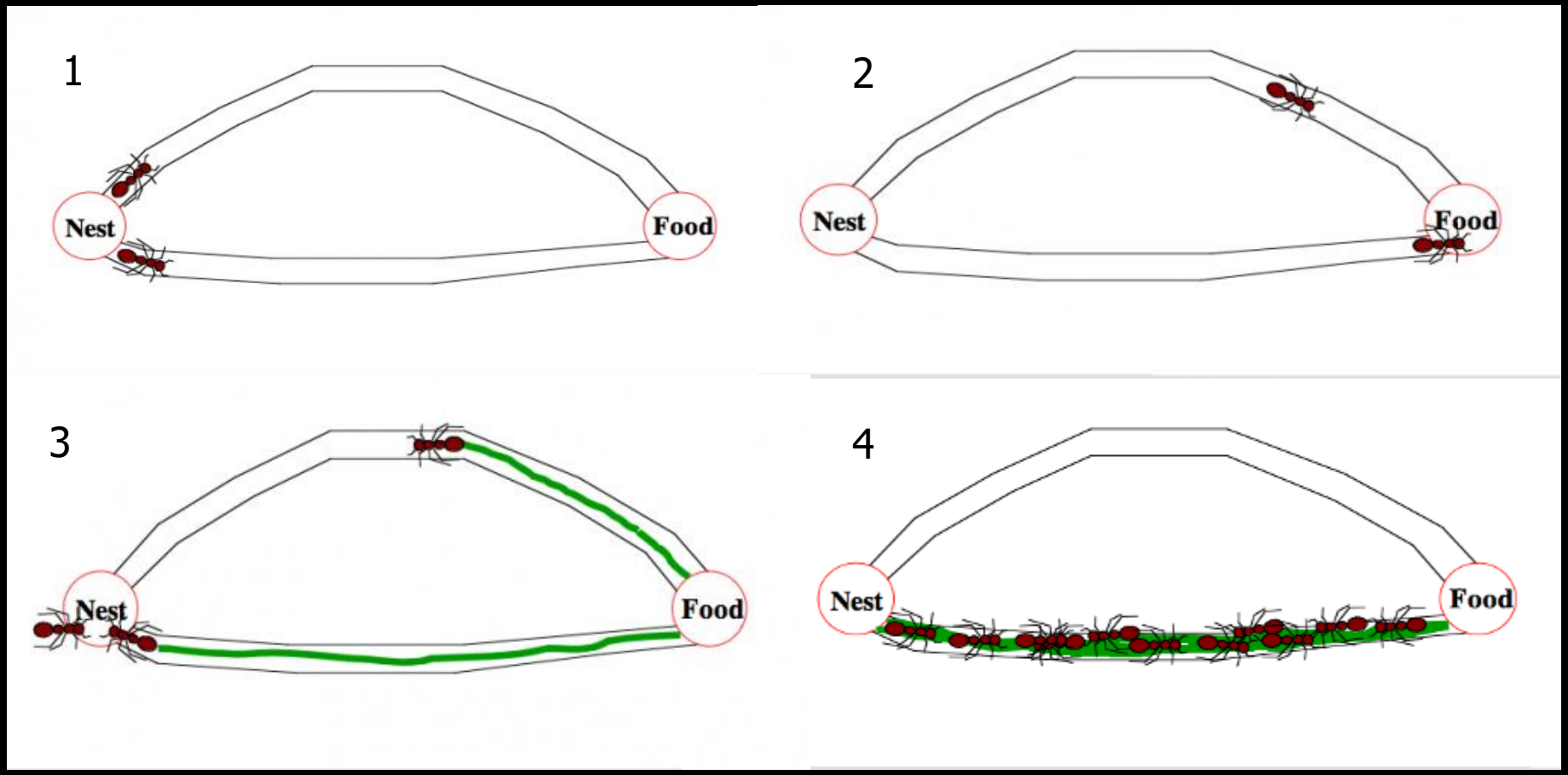
- Individuals acquire and spread information locally, interacting with their local environment – an agent is influenced mainly by its nearest neighbors
- An individual responds behaviorally to the acquisition of partial information perceived at the local scale – agents do not need to see the whole picture to respond
- Patterns of organization emerge at the global level, spatio-temporal structures that exceed the scale of an individual

- How is the information transferred among individuals?



1 *Indirect* Coordination

via modification in the environment



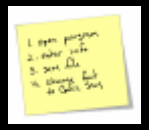
General Mechanisms

Qualitative


Maps


Wiki edits


Wasp nest


Post-it notes

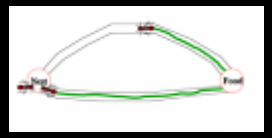

Slime molds


Wiki comments

Current state of solution

Marker-based


Nest building


Ant trails


ranking

Quantitative

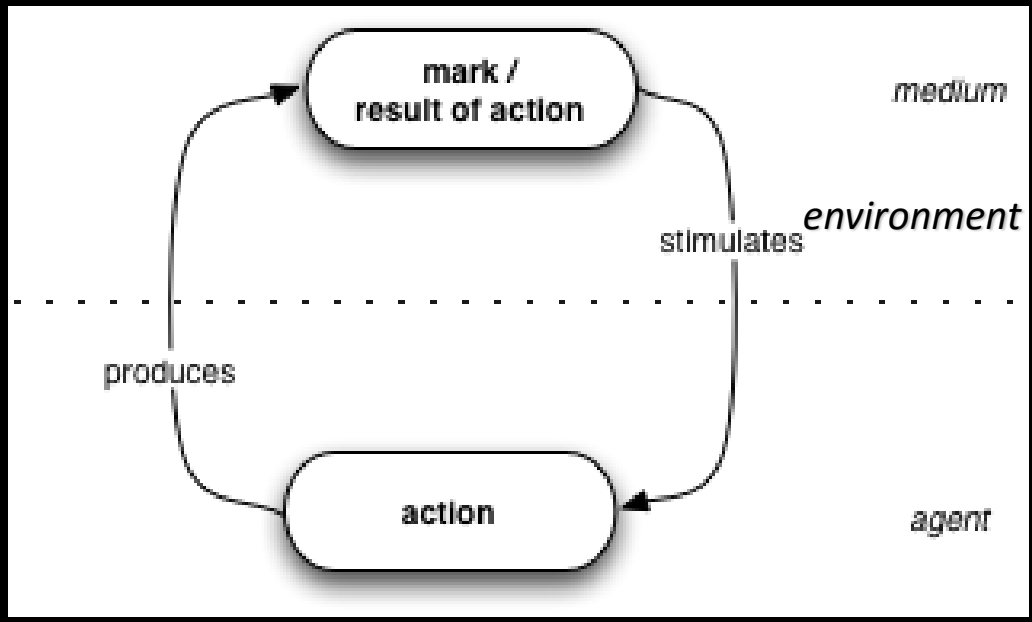
(Bonabeau, 1999, Parunak, 2006, Heylighen, 2007,).)

Stigmergy

- The work done by one agent leaves a mark/trace (stigma) in the shared environment that stimulate other agents to continue the job.

- Stigmergy operates via feedback between the agents and their environment. An action produces a modification in the medium which in turn incites a subsequent action.

It works as a Design engine that can produce structured environments. These emerging environments carry information which is critical for collective coordination



Heylighen, F (2015) Stigmergy as a Universal Coordination Mechanism: components, varieties and applications

Does it apply to the human physical environment?

Environment as Distributed Memory

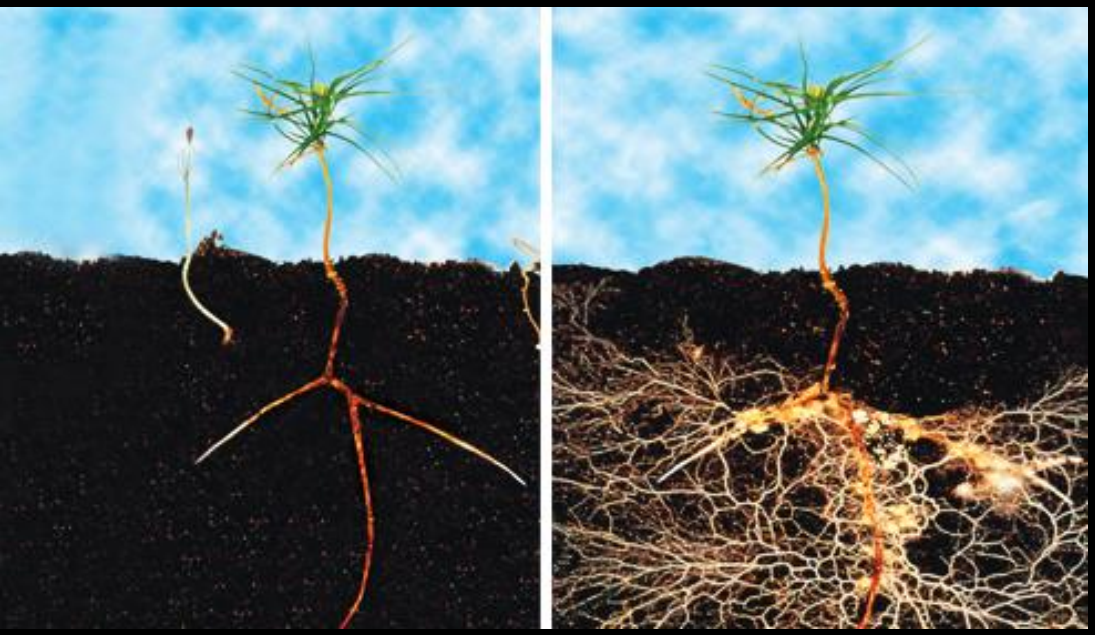
In the hypothesis of stigmergic coordination, the environment is used as a "distributed memory" for the whole system of agents

The environment produced by social processes is part of collective mechanisms of cognition

2 Mycelium Networks

Mushrooms colonize around 90% of existing plants' roots.

the centralized tree network is extended by the rhizomatic growth of the Mycelium.



Resilient

- Slow + fast

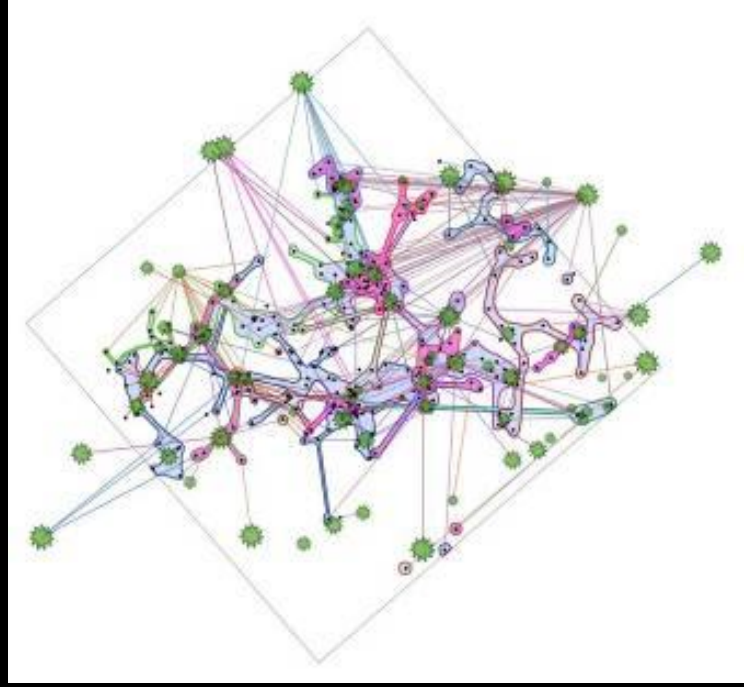
- Production (photosynthesis) + Digestion (mushrooms)
- Extended area of influence (water & nutrients)

The structural characteristics extend across multiple scales:
From the cellular scale where the interface takes place
All the way to the size of trees and whole forests

- Different plants and different species of plants are connected among them. They exchange both nutrients and signals.

- The existence of both kinds of networks allows:

  - Extras are exchanged >> Specialization of function >> Emergence of novelty
  - Connectivity among multiple organisms >> exchange of signals >> coordination
  - Synchronicity of global patterns >> Better defenses >> Resources exploitation



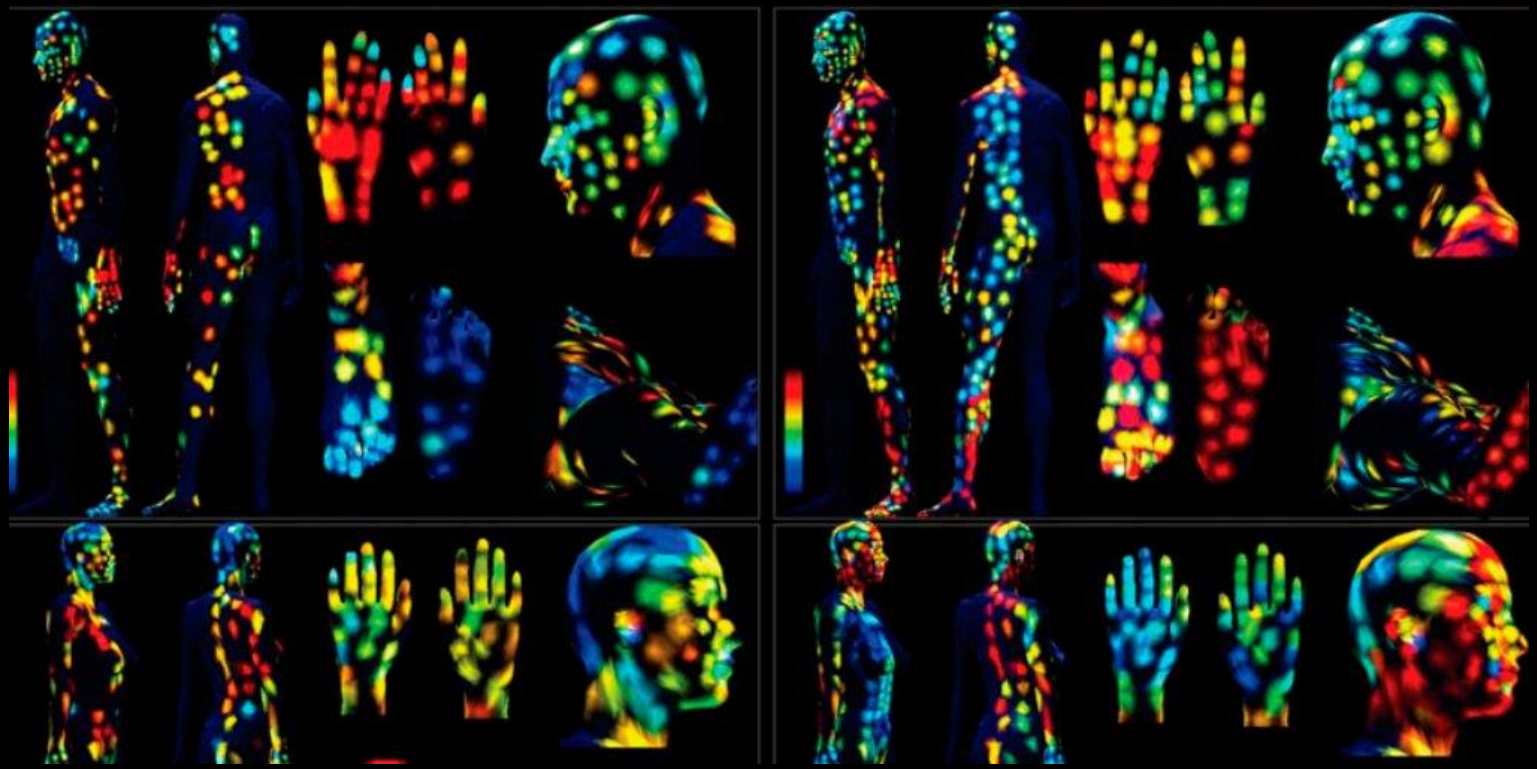
Mycelium as R&D
Explore & exploit extension
of the tree infrastructure

Simard, S., 2004, Mycorrhizal networks: a review of their extent, function, and importance

3

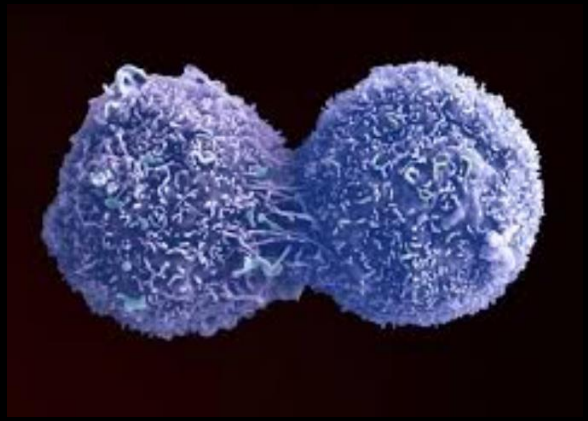
Enclosures

The majority of cells on and in our bodies are bacteria
We (our bodies) are alive more as coalitions – super-organisms – than as unified identities



Molecular cartography of the human skin surface in 3D. Bouslimani et all. 2015.

Uniquely beneficial environments promote form of communication and structure that can bridge differences, via adjacent enclosures at multiple scales



Cities as System

We find important examples of urban settlements since the beginning of civilization, some of them perpetuating their existence till the urban explosion of today. And they are very resilient in structure

Cities are the most extensive and repeated collective pattern of the human specie

"what is the function of cities?"

What does it mean to enable urban function?

Cities as Complex Adaptive Systems

Local interactions among a large number of components can lead to global forms of organization which are non-predictable from the observation of the parts alone

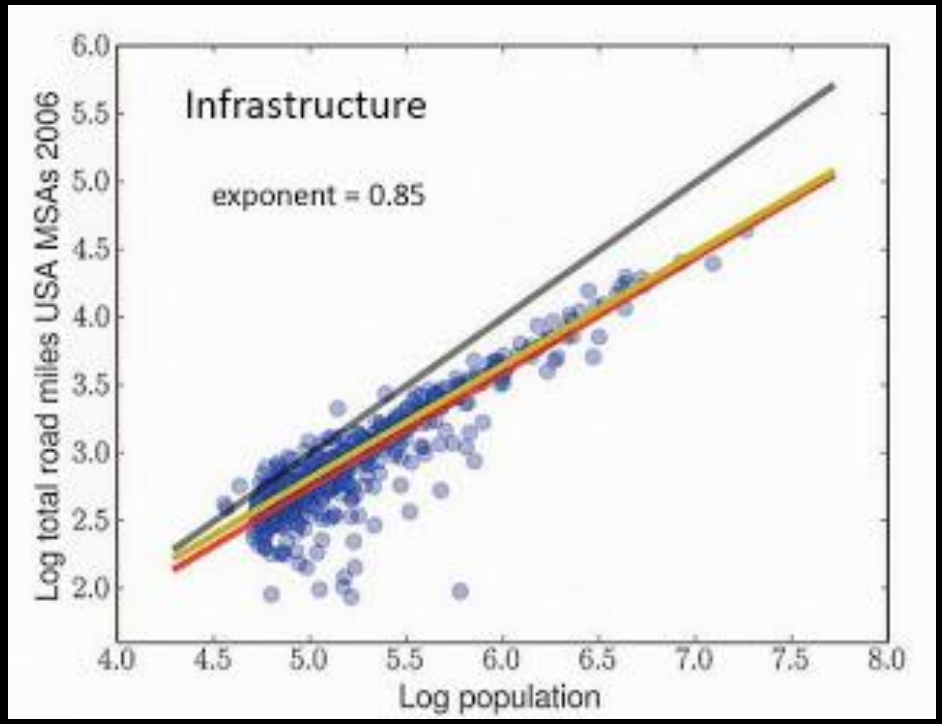
- Do we observe Global Patterns?

  Of course, many.

  A growing body of studies shows deeper structural and behavioral patterns

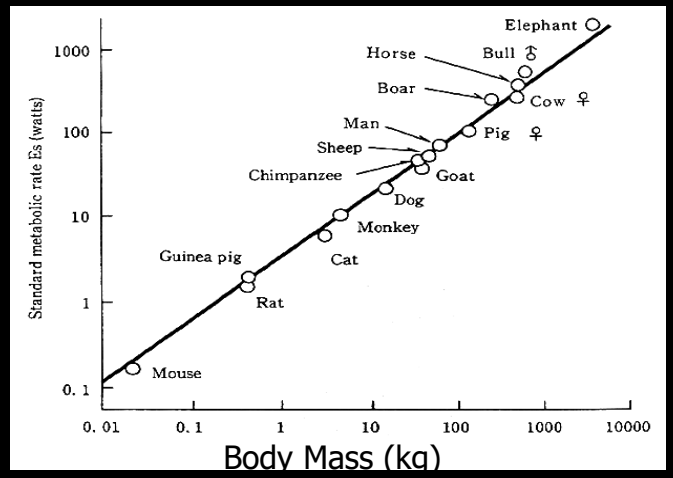
Economy of scale

With the growing of the size of a city, less pro-capita consumption happens. Larger cities are proportionally denser and citizens are consuming less (water, electricity, gasoline).



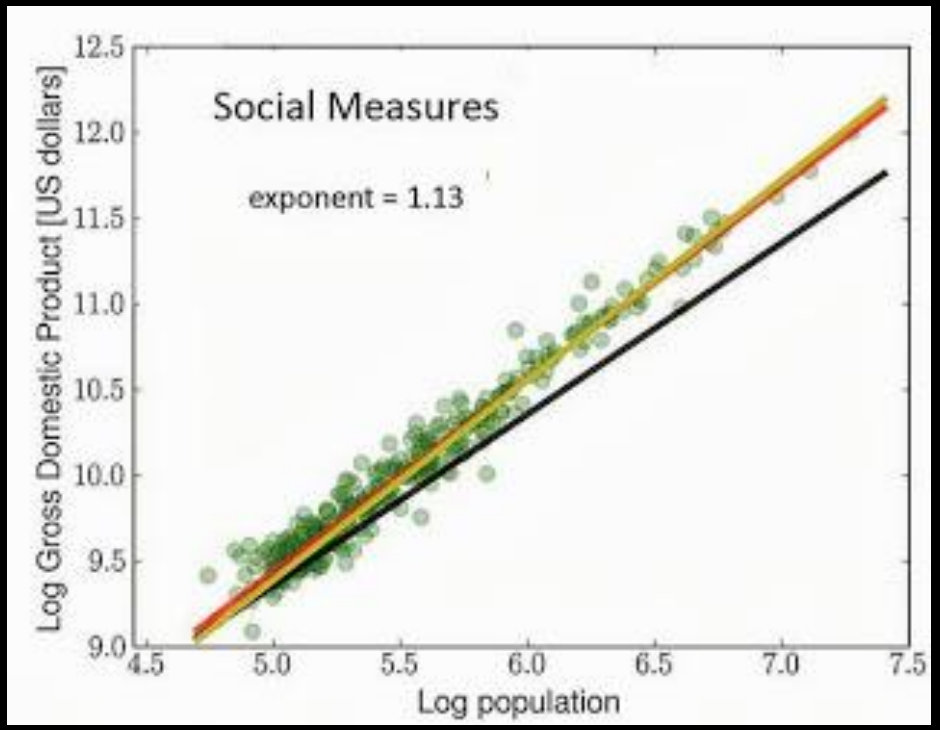
Bettencourt, L.M.A., West, G. B. (2010). A Unified Theory of Urban Living, Nature 467:912-913.

Living Functional Systems?



Supra-linear Growth

With the growth of the size of a city, the pro-capita income, the number of patents produced per year and life rhythms increase exponentially; as well as costs, crime, traffic and stress.



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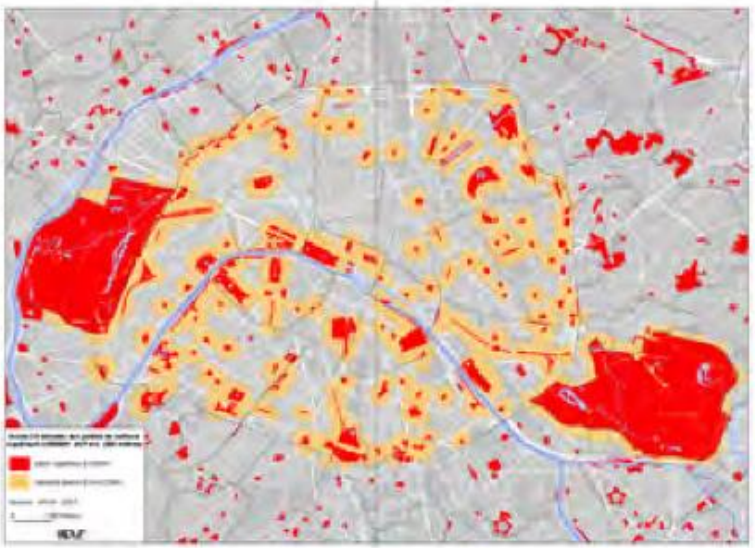
Social Accelerators?

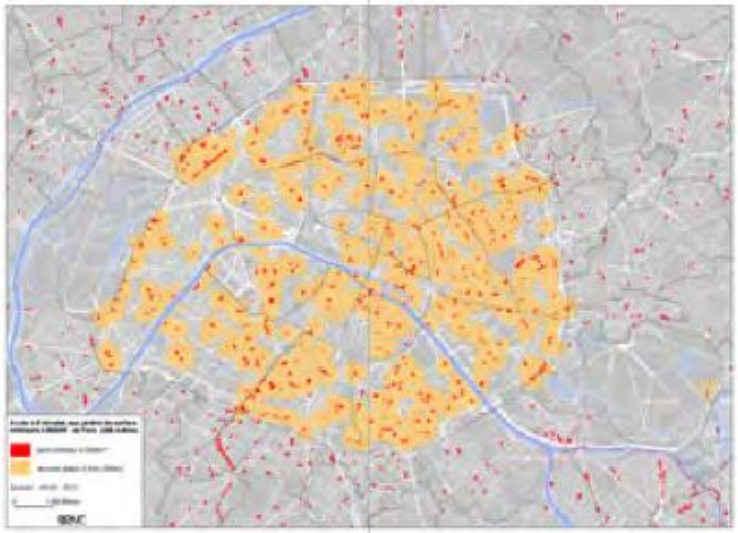
Cities as uniquely evolved functional environments

that naturally evolved to balance the advantages of agglomerated sociality (i.e. innovation, wealth, cultural stimulation), with its costs (i.e. congestions, criminality).

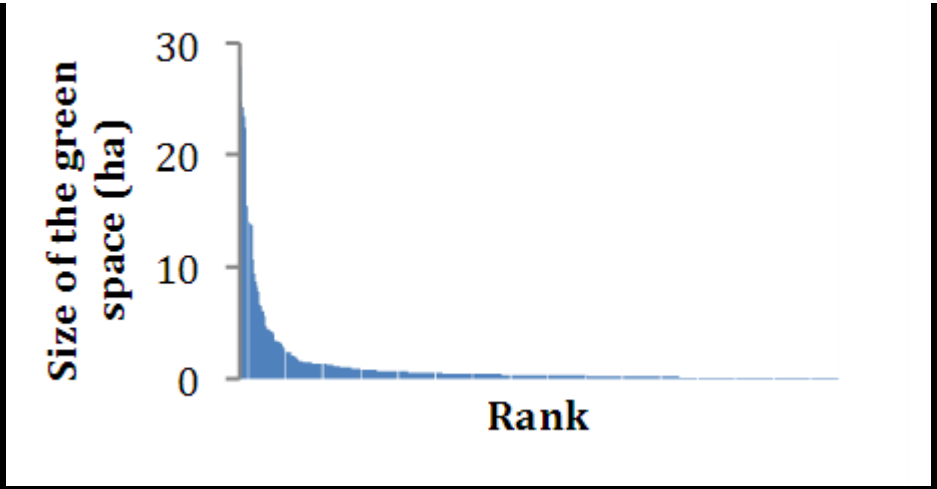
Fundamental to human distributed cognition and memory (or to their dis-functionality).

Urban Morphology and Complexity



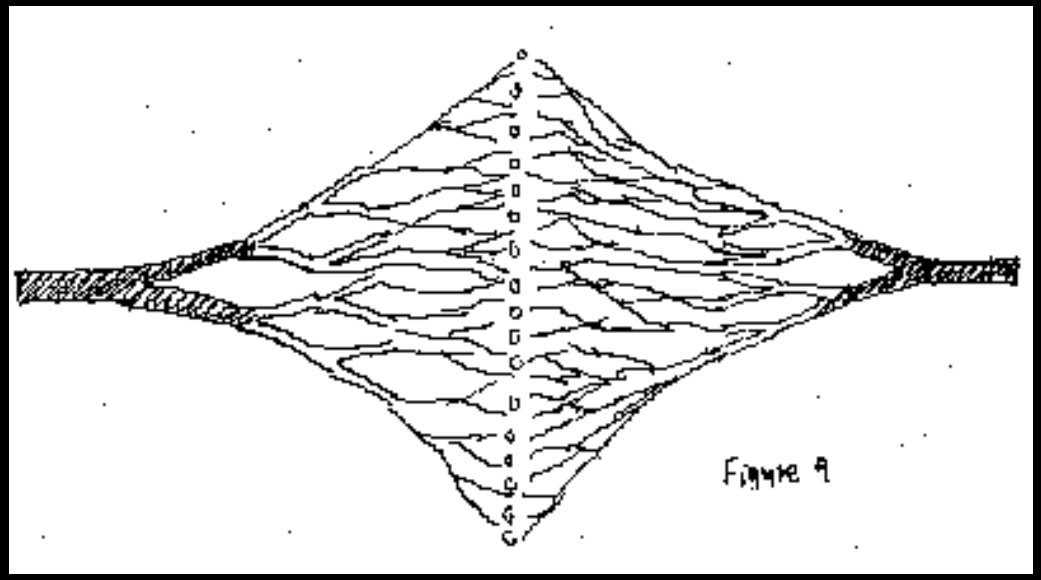


Historical Cities



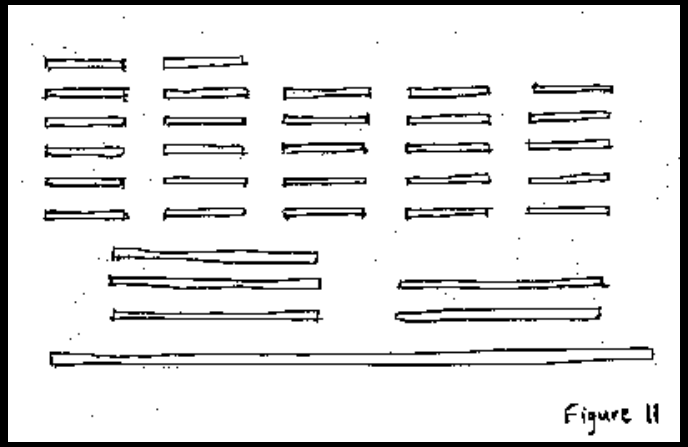
Salat, S., Bourdic, L., Labbe, F. (2014). Breaking Symmetries and emerging scaling urban structures: A Morphological Tale of 3 Cities: Paris, New York and Barcelona.

Cities as Social Networks



The exponential behaviors of cities can be explained by the behavior of networks embedded in space

The fractal distribution of sizes is also a characteristic of networks



Multiplicity of Scales

Human size “Places”

Salingaros, N. (2008). Principles of Urban Structure. Amsterdam, The Netherlands: Techne Press.

Physical & Social Flows

Complexity: The impossibility to know and fully plan a priori

The necessity to:

- diagnose and prototype

- Design public environments that support spontaneous collective coordination for the exploration of solutions

- Relate to cities not as ‘just’ artifacts, but rather as human society embodied physiology

Thank you

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