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Self-organization, Growth, Organization etc.
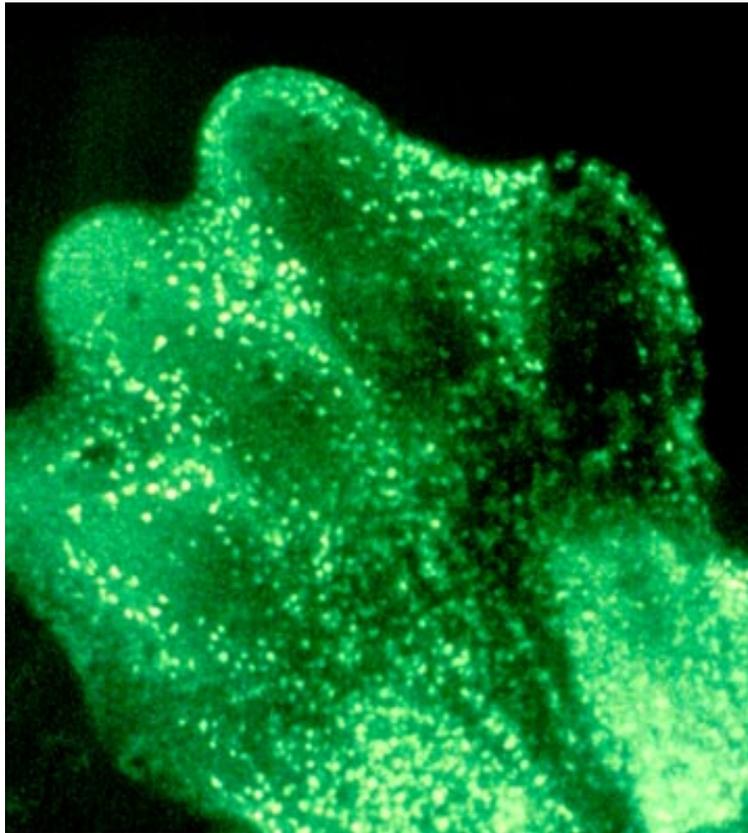
Complexity and its Neighbourhood

embedding Reaction-Diffusion Systems

ETH
Eidgenössische Technische Hochschule Zürich
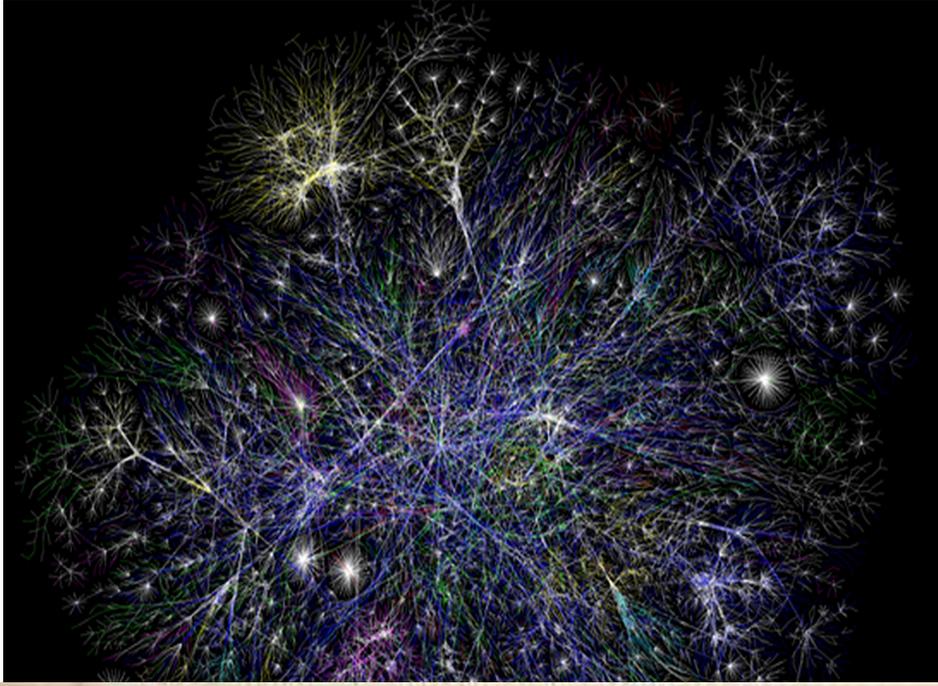Swiss Federal Institute of Technology Zurich

The Living

The Social

Technology

Ideology

Complexity

... what „is" it?
... what is its „meaning"?
... how to make sense of it?

Conceptual Surrounds

... the New
... pattern formation & growth
... evolutionistic phenomena
... networks

Outline

Bird's View: Methodological Aspects

Complexity: What „*is*" it?

5 Elements of Complexity

Elementarization as a Technique

Meaning of Complexity, how to deal with it

Pattern Formation and 3/3+3 Models of Growth

#1 Methodology + Theory

(just a bit of reflection)

Methodology ...   which methods are out there?

how to apply them?

There is nothing without method, model or theory

(the not insignificant problem of how to deal with rule-following)

„The world is...“   number, name, machine,   Pythagoras

machinic, computer, complex

name   William of Ockham

Mode of Explanation   **mechanism** global OR local ?

machine   Descartes...Schrödinger

Theory   a set of rules about how to
create & parametrize
(more) formal models

machinic

computer   Wolfram

complex   Deleuze

#2 Complexity: What is it?

the kinship of the „is"...

reality, causality, objects, identity,
measurability, controllability, ...

„is"-questions are threatened by striking naivity:

there is not even the smallest perception
without activity, without precursory models
and theory,

there is no such thing, which just „is" there

primacy of interpretation

Complexity: Perspectives

There are (only) a few basic perspectives:

traditional...   (1) ontology The world, its substance and being
                     (2) epistemology and what to know about it

meta-traditional... **(3) onto-epistemology**

These views answer questions about ...

- fundamental issues of being and becoming (1)

- conditions for perceiving, conceiving, knowing and their possibilities (2)

- construction of worlds, their a priori conditions and their respective (quasi-)logics while performing (3)

Complexity: Reflected Recall

„Is" there complexity in the outside world? (No.)

We always need some theory, which can never
be empirically justified completely

There is **always** some „metaphysical" element
in any theory and in any practice

Don't fight the inevitable, instead turn around…

The starting point for any synthesis is *always*....

a set of (metaphysical) **<Element(s)>**

Complexity: Field 0

it consists of „elements"

it is a construction

it is an onto-epistemological bridge between
analysis and synthesis

- empirical measurement inside emergent processes
- creating maps, artificial movement
- controlling the structural level partially
- model system for novelty

**it may be used as a
meta-formal framework
for productive entities ...**

*living beings, social groups, cities,
open computational procedures, brains, ...*

The Being of Complexity: its Elements.

5 Elements for explaining/constructing Complexity

- at least one reaction-diffusion-process, which consists of a population of two particularly configured types of processes

- dissipative processes (currents of entropy)

- standardization (genotype, phenotype, semiotic)

- active compartimentalization , transition from order to organization (includes left-overs, death)

- systemic knots in topological relations, it is inevitable in stacked systems of emergences, and it inevitably creates a 2nd-order reaction-diffusion-processes
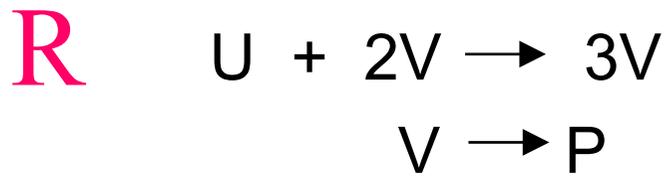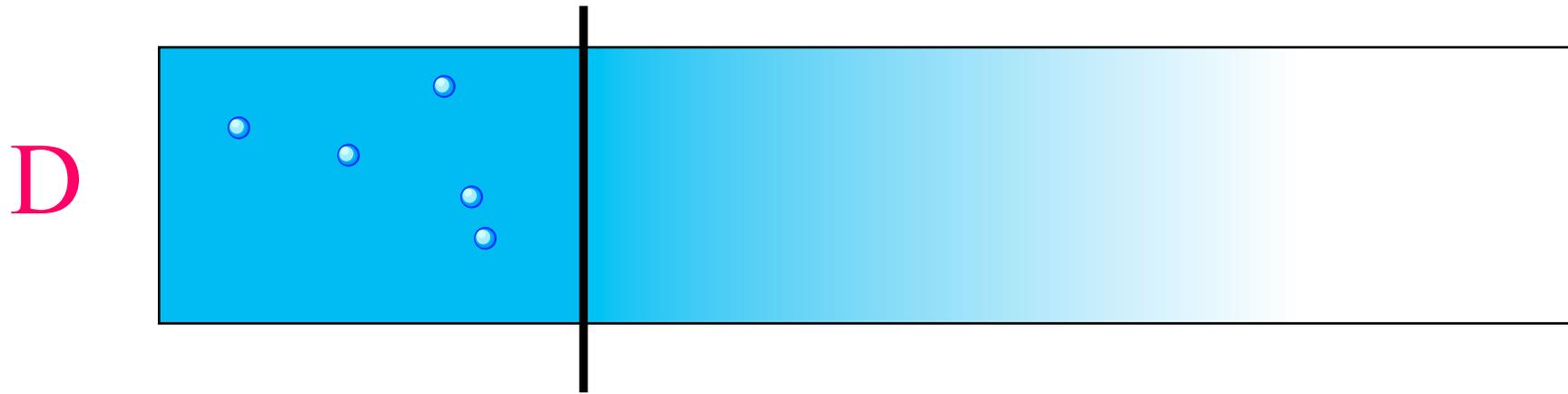
Advantage: the rather opaque concept „complexity"
molts into a **parameter space**

E1: Asymmetry in RD-Processes

Weak Far
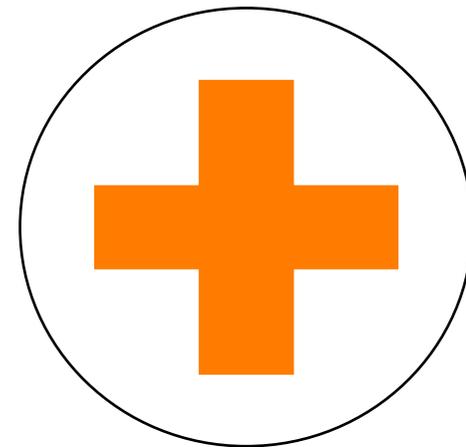
Strong Near

Diffusion + Reaction

D

R U + 2V → 3V   net flow = U → P (removed)

         V → P   catalysator : V

Gray-Scott model = flow reactor system

Scenarios for Reaction and Diffusion

$U + 2V \longrightarrow 3V$ $\quad$ R_A

$V \longrightarrow P$ $\quad$ R_B

$R_A << R_B$ $\quad$ $V = const.= dV/dt = 0 , \quad U>>0$

$R_A >> R_B$ $\quad$ $dV/dt > 0, U=0$

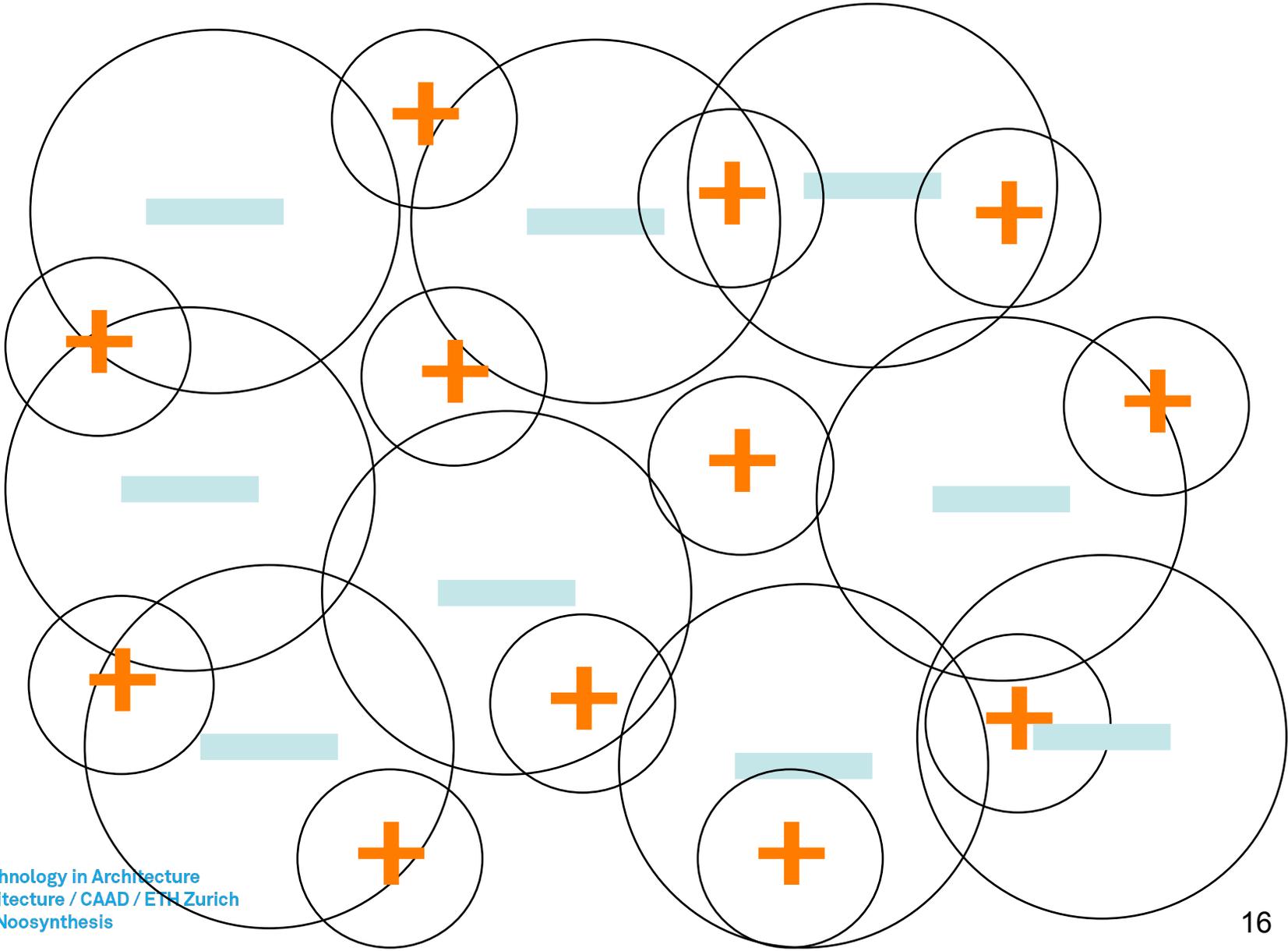$R_A = R_B$ $\quad$ diffusion becomes more important

$V = P$ $\quad$ self-referential system

immaterial, informational

RD-Processes as/in a „Population"

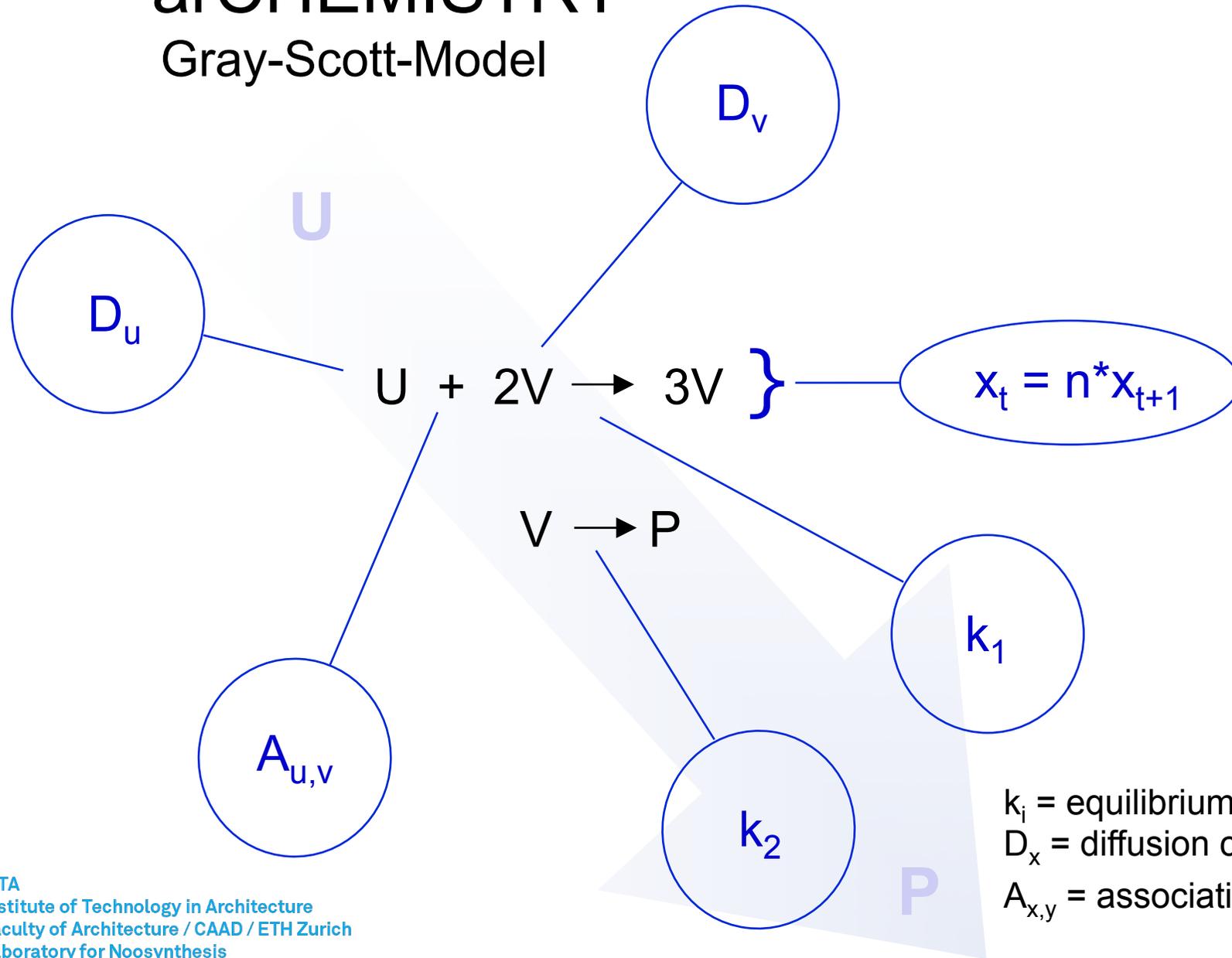trembling, microscopic movement

RD-Processes: Sorting out

long-range correlations transcending randomness,
based on pure chance, but definitely no white noise;
far less „predictable" than any similar random process

selection
growth

absolutely
„impermeable
epistemological
separation

Descriptional categories can NOT be mutually applied to each other level !

molecules, cells, ants, words,
events, people, actors in a network

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arCHEMISTRY
Gray-Scott-Model

D_v

D_u

U

$$U + 2V \longrightarrow 3V \;\}$$

$$x_t = n * x_{t+1}$$

$$V \longrightarrow P$$

$A_{u,v}$

k_1

k_2

P

k_i = equilibrium constants;
D_x = diffusion constants ;
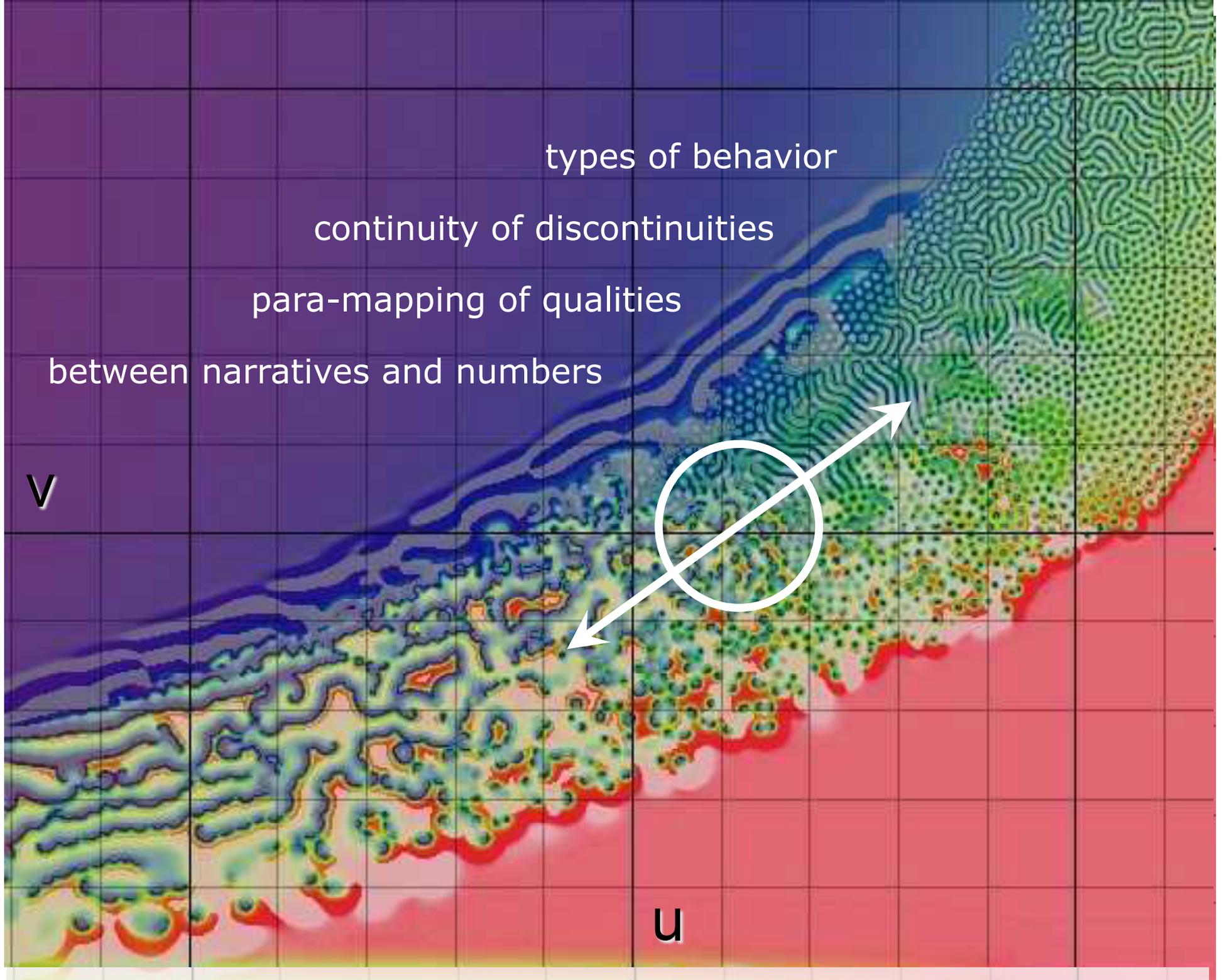$A_{x,y}$ = association constant

types of behavior

continuity of discontinuities

para-mapping of qualities

between narratives and numbers

v

u

ARCHemistry ("relational architecture")

$$U + 2V \longrightarrow 3V$$

$$V \longrightarrow P$$

$$\vdots$$

U : ?

V : ?

P : ?

main rules: transcend cybernetics!
cultivate antagonism!

5 Elements: next one...

reaction-diffusion-process,

dissipative processes

standardization

compartimentalization

systemic knots

The Role of Standardization

levels and types of standardization:

codes and/or rules

without a priori standardization

no interpretation, no interaction, no transfer,
no influence, no emergent patterns

emergent patterns = long-range correlations

standardization on a next level

efficient standardization is NOT a self-creating natural quality!

The Role of the Compartments

created by repeated patterns

established by more or less permeable „membranes"

C. represent the transition from order to organization, initiates historicibility, aging, learning, externalization

C. are the „particles" of the next level in the progression to complexity

they need not to be spatial:
may by temporal, functional as well

Now knotting everything...

basic units for emergence...
antagonisms, entropy current, standardization

memory and historicibility...   (capacity to create history)
compartmentalization

the same game on the next level
population of compartments interacting
population interacting in compartments

cross-level self-monitoring, cross-level-reactivities
incomplete mapping from top to down
auto-generated contradiction

Complexity:
Principle for Living Interestingness

social groups, markets

organism

organs, e.g. immune system

tissue

cell

signals

organelles within the cell, membranes

proteins

Genome

DNA

increasing integration
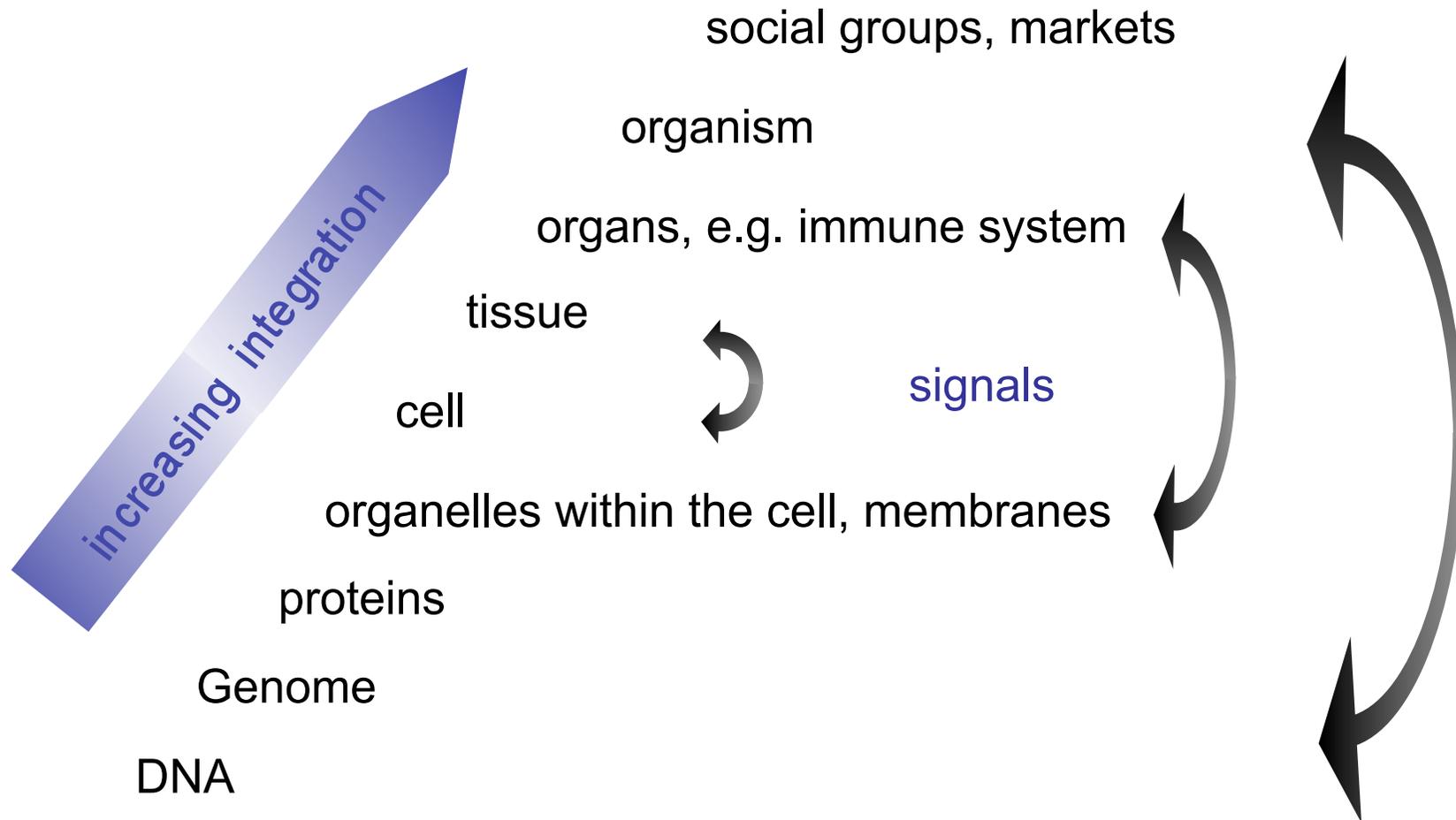
Complexity: What is its „Meaning"?
part 1

1. without self-sustaining complexity
   nothing new will ever happen (=no creativity)

2. without the <NEW> (built-in autonomous creativity)
   any arbitrary system will fail to be adaptive

3. allows to revert the direction of asking...
   (oh, it is complex...) where is the standardization?
   where is the antagonism (primary, secondary)?
   which are the compartments?

4. or: why did it fail to become complex (adaptive, etc.)
   = which factor is missing?

Reasoning about Causes (I)

Levels of regulation?

Types of Processes?

Is there a gene for this pattern?

...and another one for that one?

...or, if a gene at all, just one for D_u ?
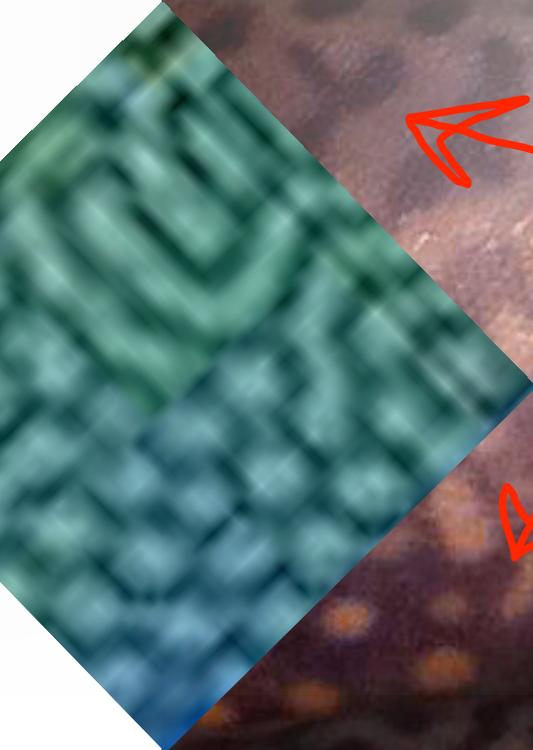
Reasoning about Causes (II)

same processes?

Pattern Formation

... is this a layout of a city?

... of which one? // ... why not?
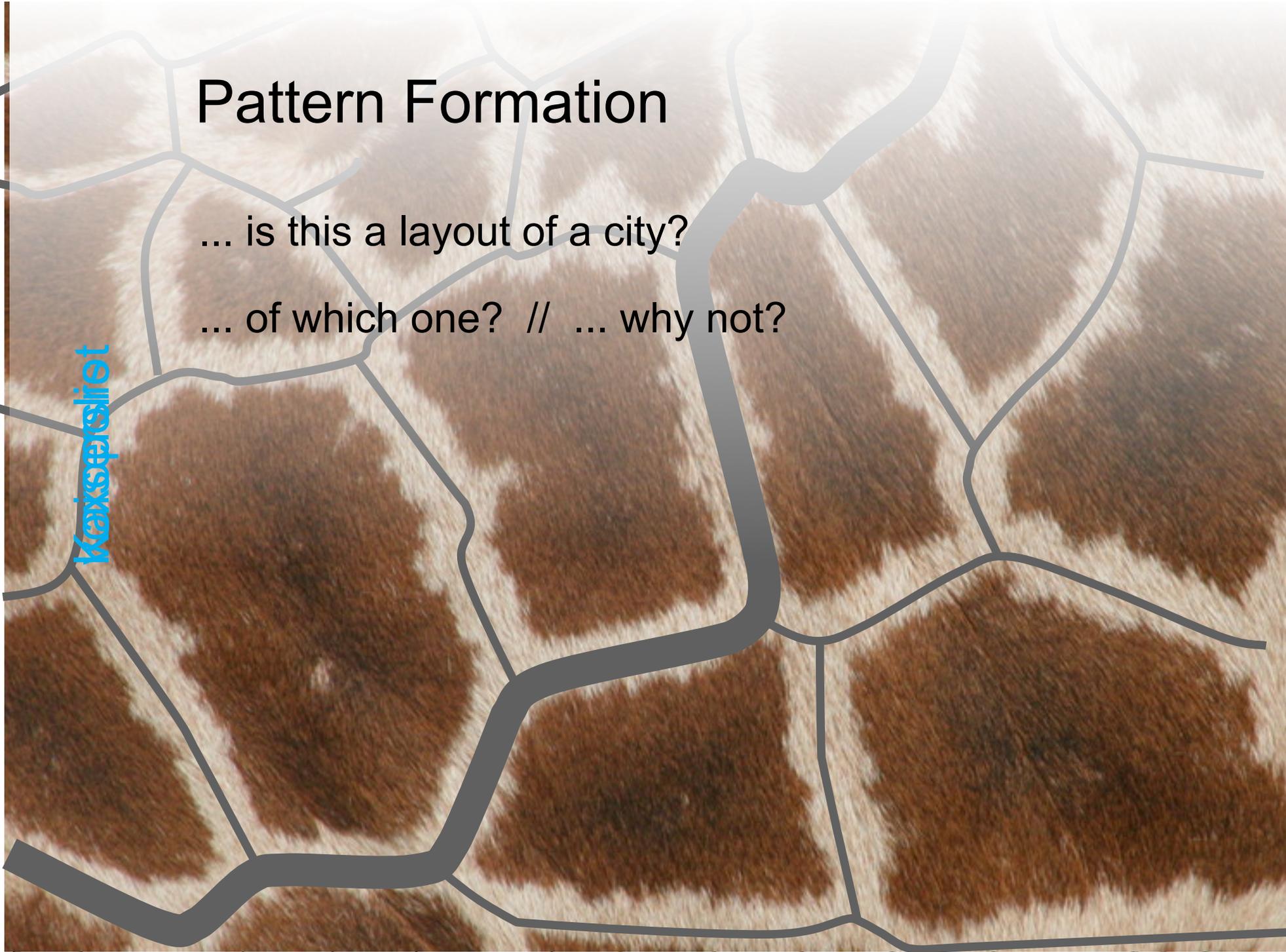
Complexity: What is its „Meaning"?

C_{5E} alllows to visualize the dynamics of the differential

provides a mapping quality discontinuities

is a non-representational, meta-cybernetic perspective
to the (symbolic) productivity of a <dwelling, city>

Relevance for humans: $\partial^2 > 0$ (change of changes)
                          ... docking station for symbolification

linked: the <new>, adaptiveness, interestingness,
          complexity, antagonism, order $\longleftrightarrow$ organization,
          expectations $\longleftrightarrow$ symbolification

Future Research: „Beyond Emergence"

Artificial Embryology, Artificial Ontogeny (material)

Artificial Behavior (immaterial)

> ... „(artificial) evolution" alone does not explain „new" solutions
> describes order-organization transitions only partially

... focusing on **growth of structures** (or behavior)
will solve the hen-egg-paradox, which is important for
autonomous anticipative systems
(far beyond cybernetics)

how to deal with floor plans? city layouts?
`what are the elements of „cityness"?`

#3 Models of Growth

crystalline

mineralic

Slime Molds,
Fungi (mushrooms)

Plants

Animals
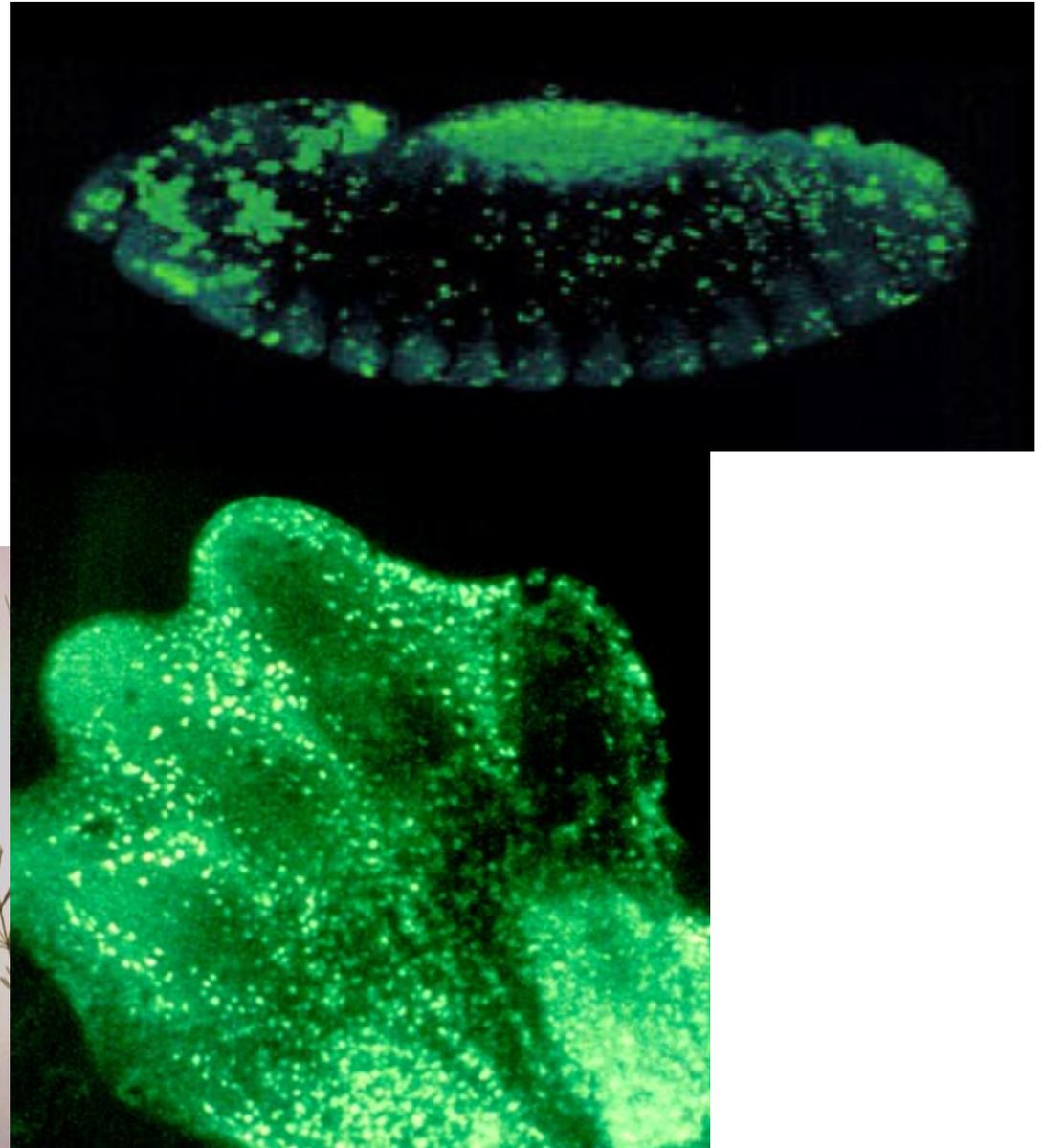
Models of Growth

for the sake of historical completeness...

growth patterns of crystals are the MOST simple patterns !

they grow along the GRID of atomic or molecular bonds,
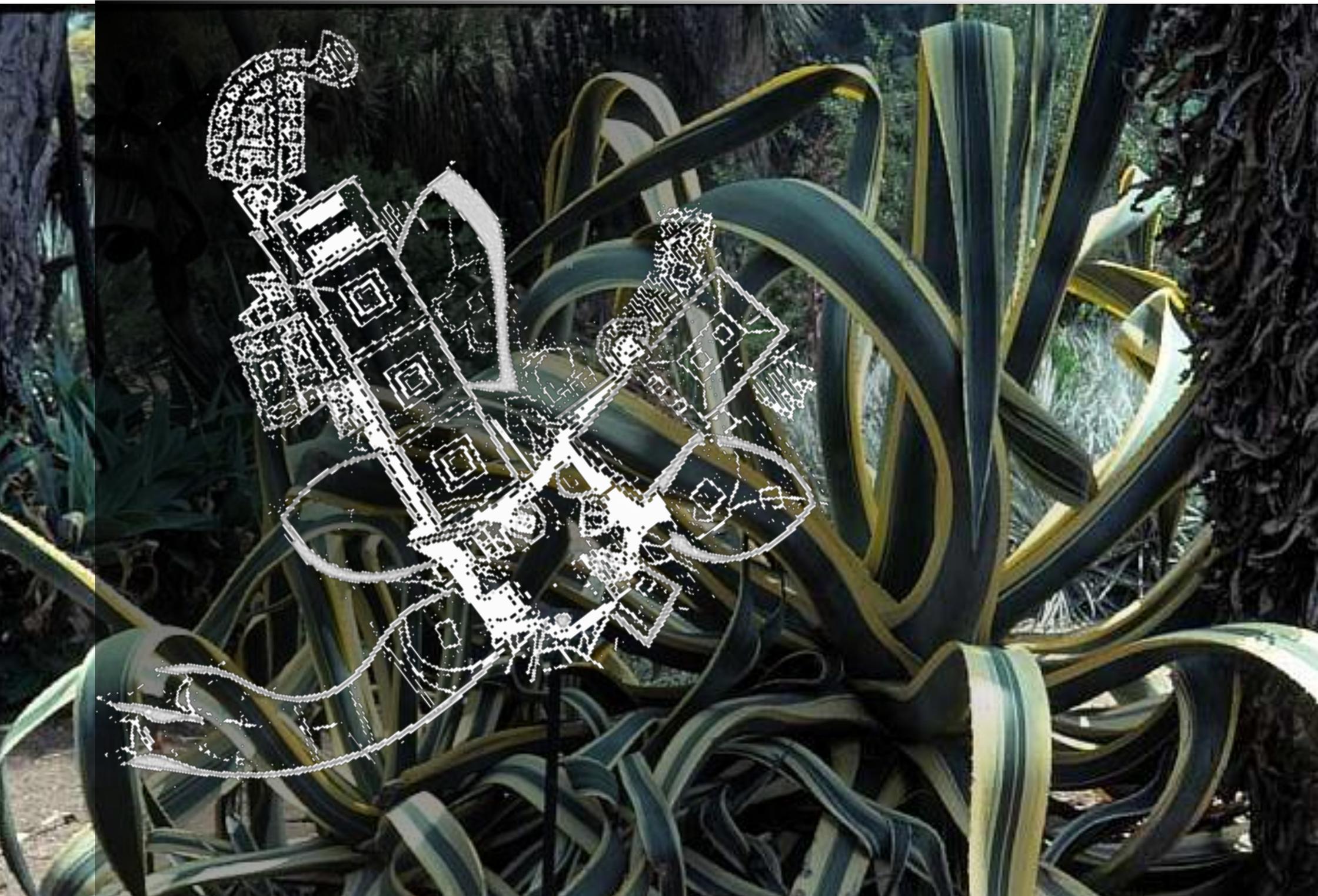it is a linear, physicalistic, positivistic, de-individualizing pattern
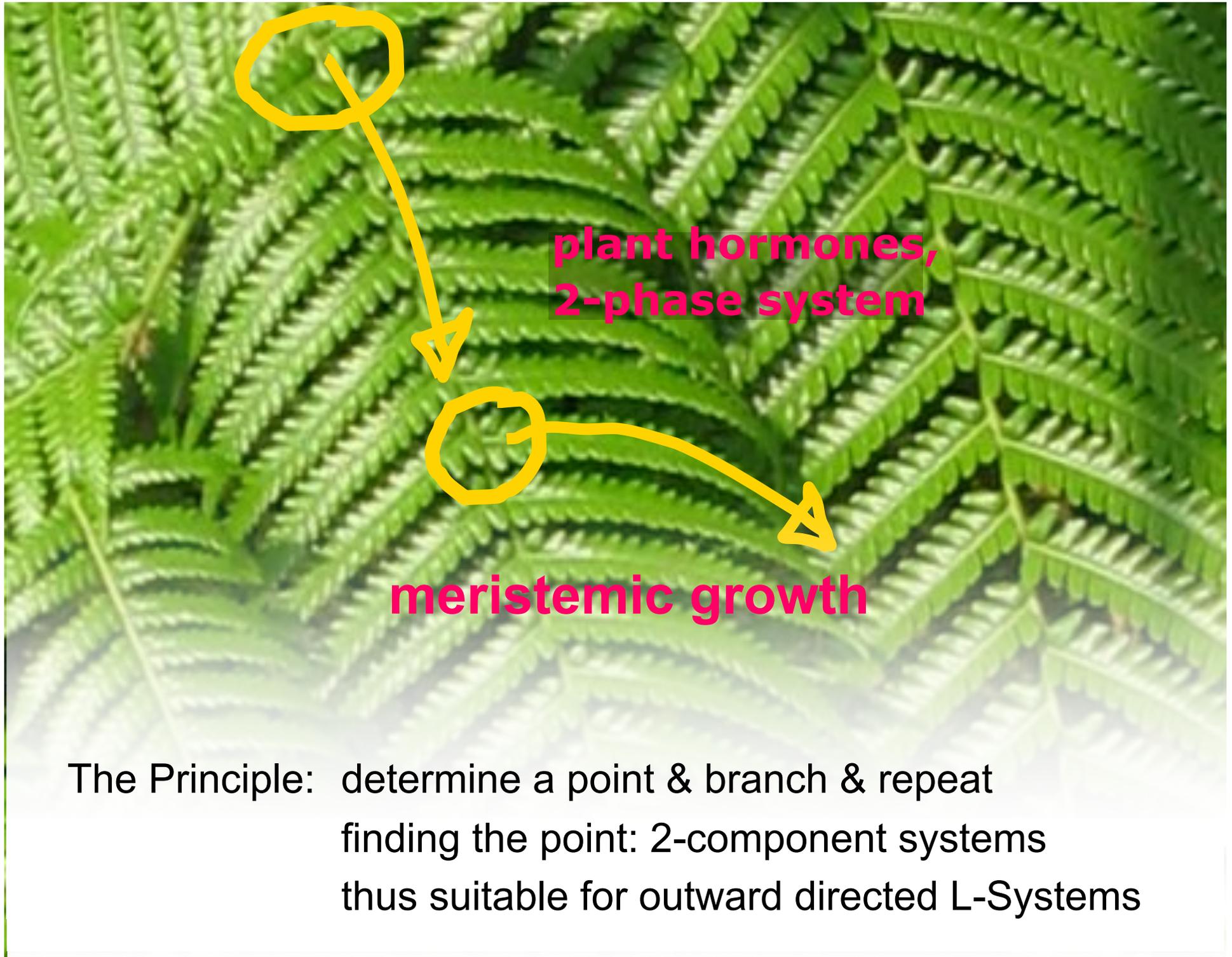
plant hormones, 2-phase system

meristemic growth

The Principle: determine a point & branch & repeat
finding the point: 2-component systems
thus suitable for outward directed L-Systems
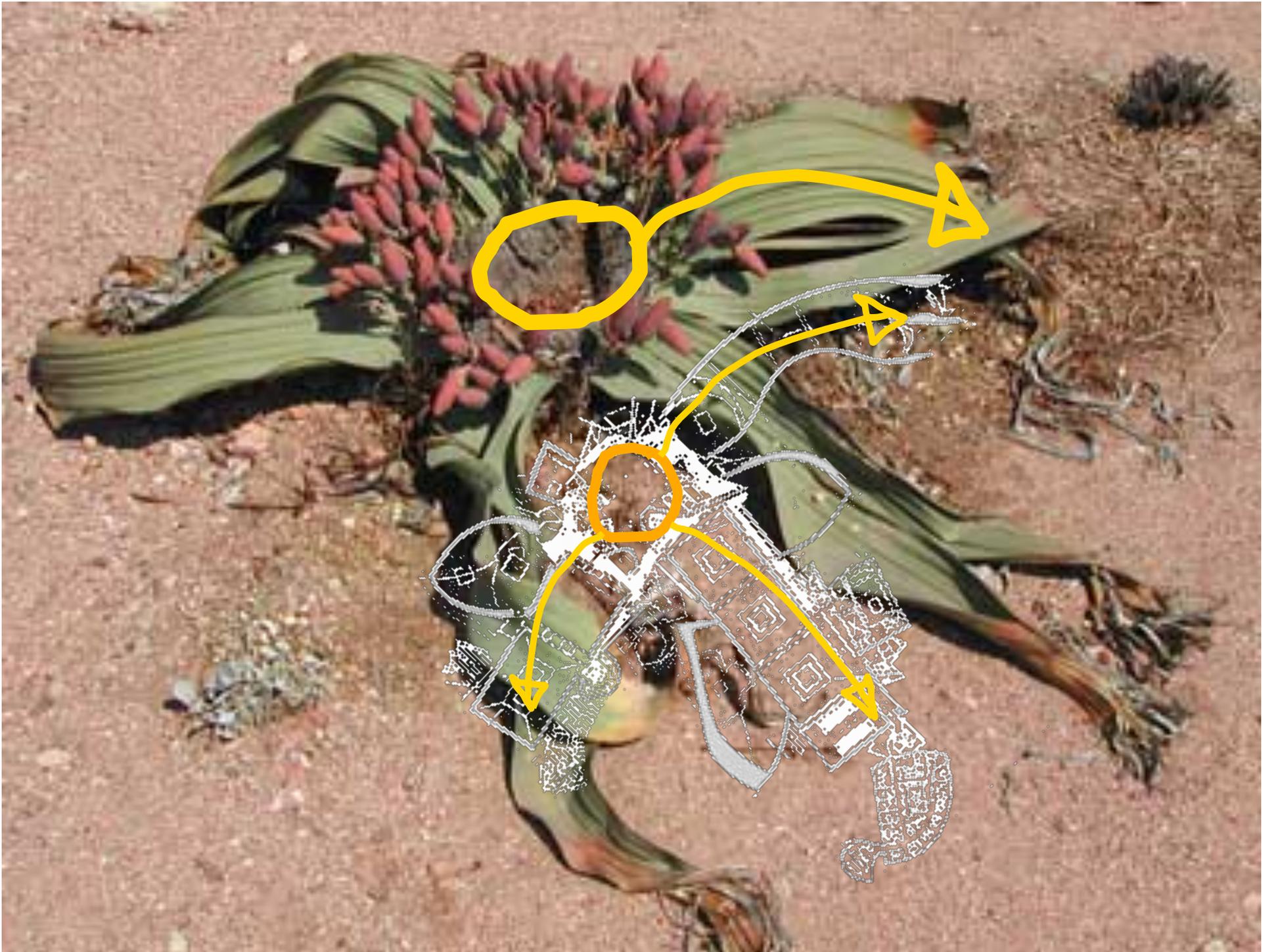
Growth from Origin, by Attachment

typical for plants:
2-component-system at points of origins (meristeme)
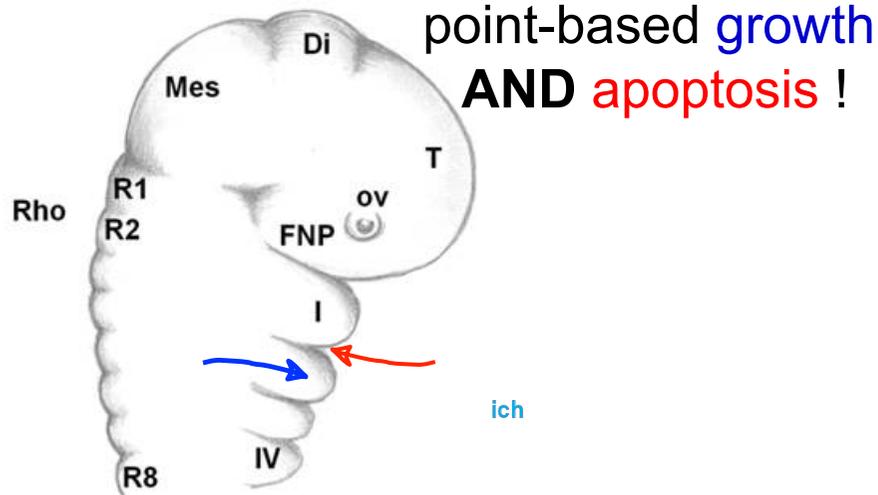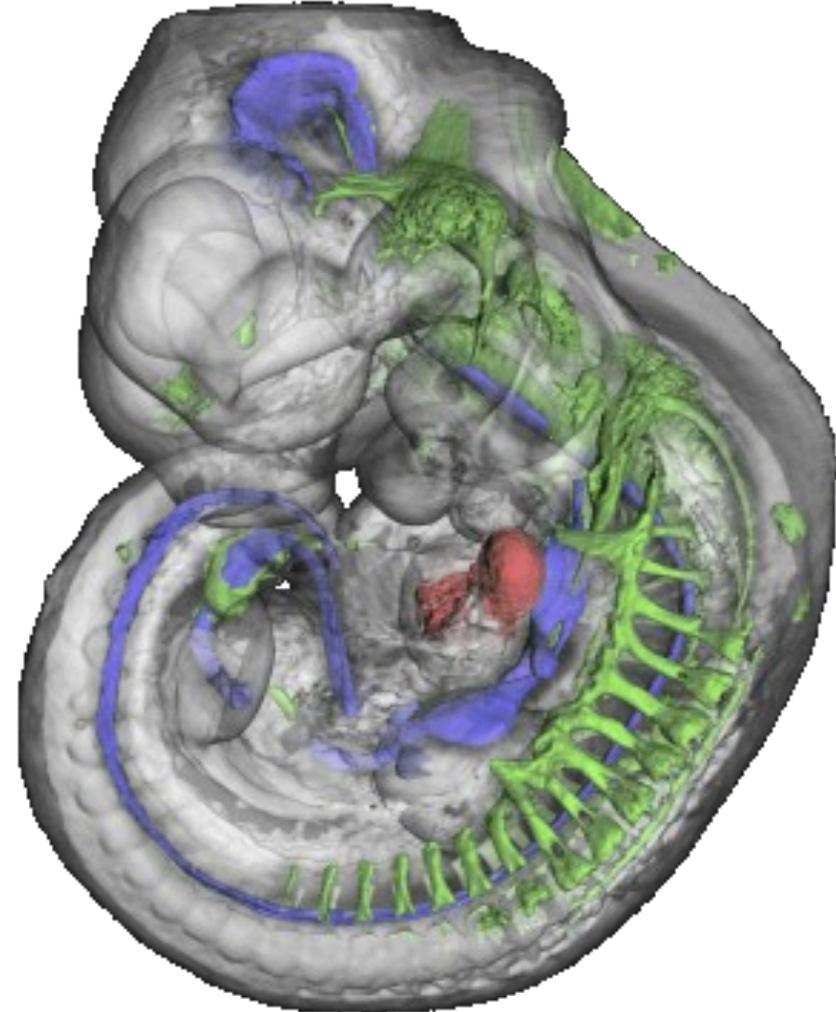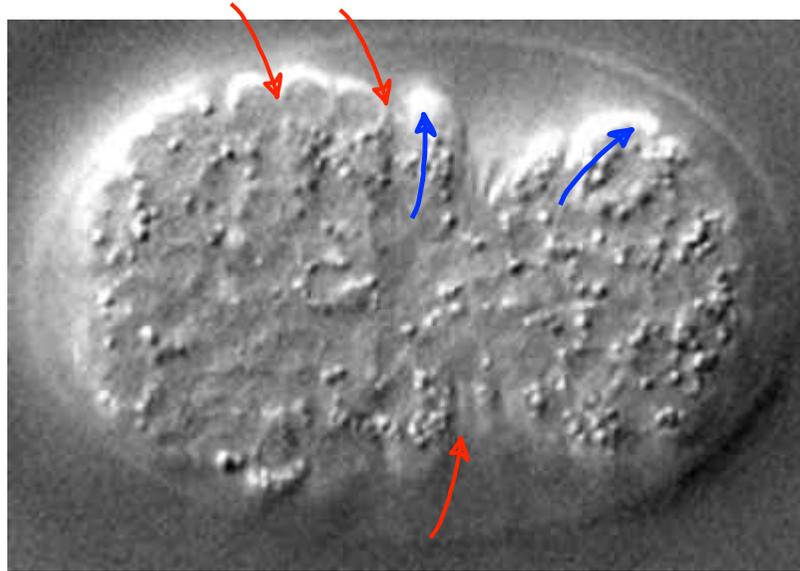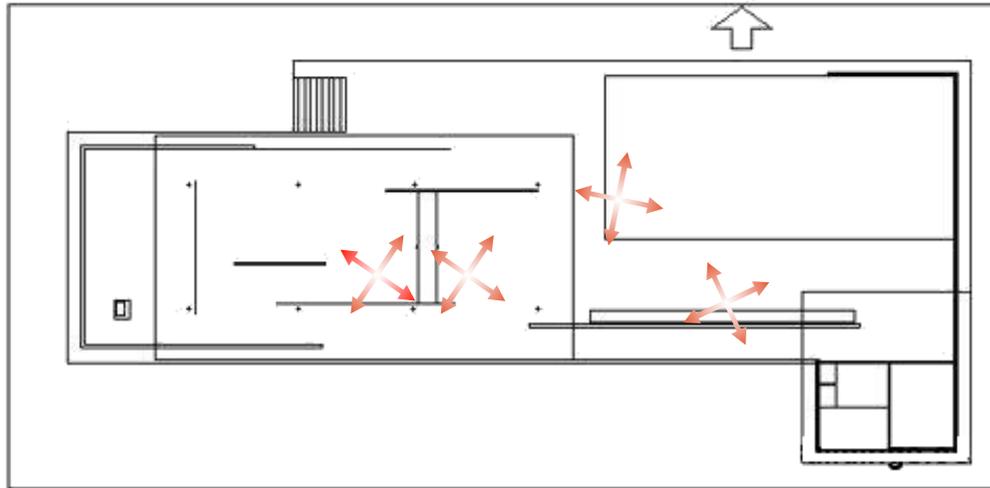fractal growth

Plant
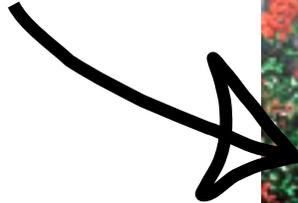
Plant (-like)

Folding, melting (moving) = Animal Embryo
differentiation towards the inside, highly complex dynamics

point-based growth
AND apoptosis !

Inward-directed Differentiation

enfolding inside / outside

· Barcelona Pavilion · Barcelona, Spain

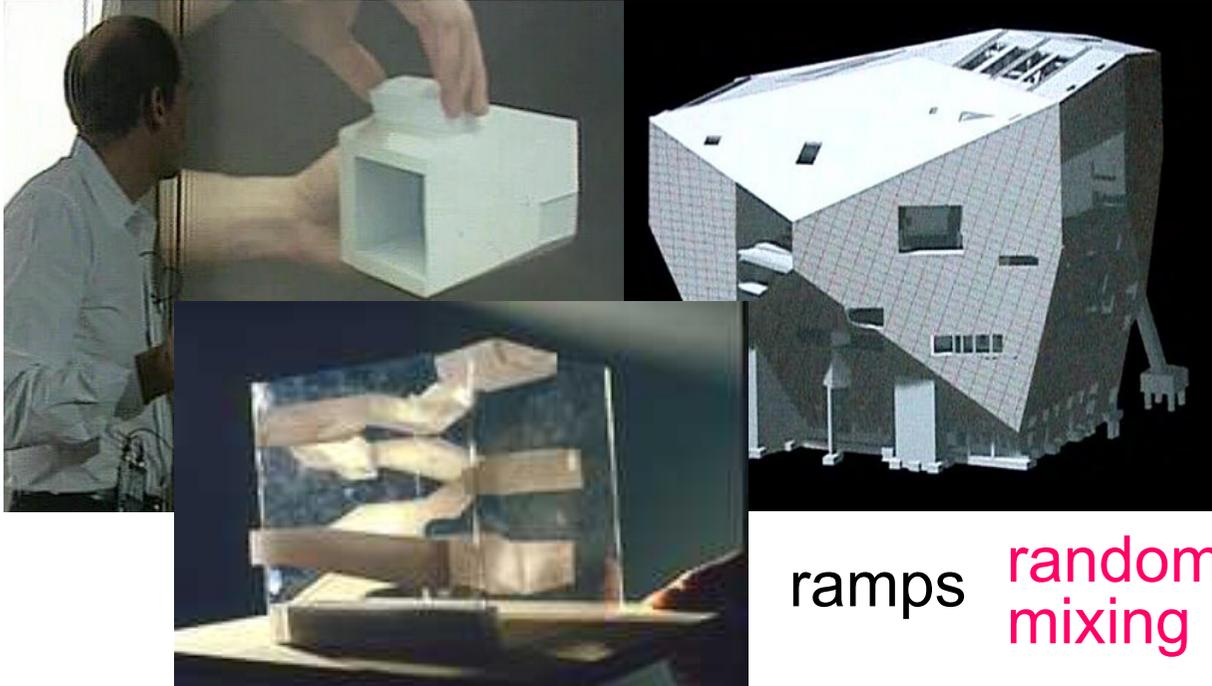assignment of „inside" / „outside" has to be negotiated: antagonistic forces at work, →emerging „immunotropes"

inner compartments may be re-arranged: *potential melting, fusion of spaces and of membranes*

Koohlhaas, the Embryologist?

Koolhaas Constants   boxes, boxes in boxes   nested compartments

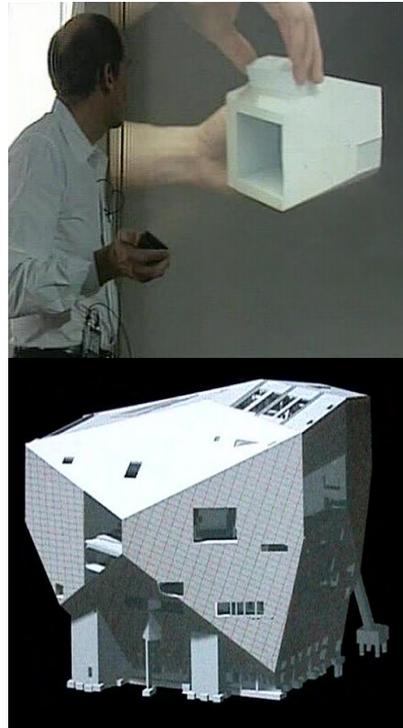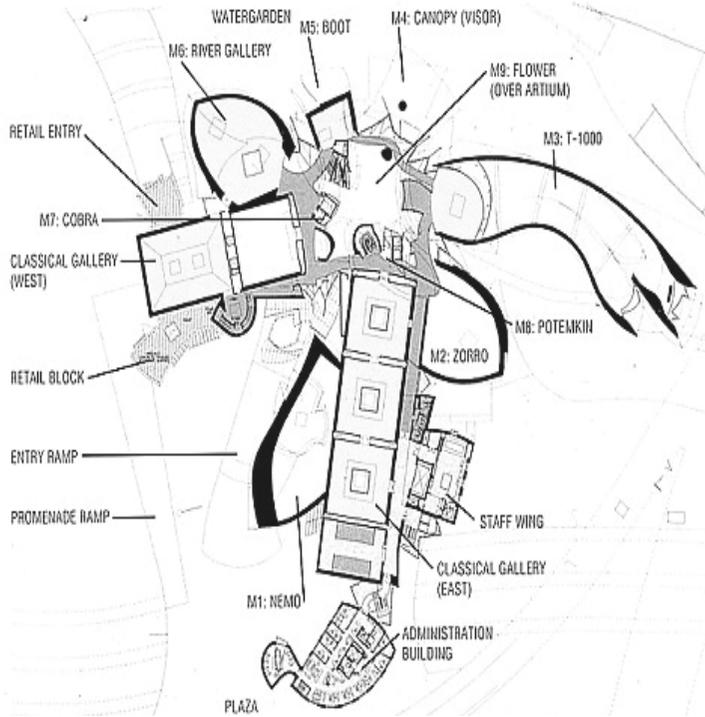scripts for contrasting experiences

antagonism

ramps   randomized mixing   entropy

... all of those have direct equivalents in embryology

embryology tells us further: melting tissues (apoptosis) & moving cells leads to inward differentiation, organized by C_{5E}-„complexity" in the liquid phase

Bionic Models of Growth

plant-like

animal-like

swarm-like

space-time structure

separated

contiguous

emergent

sessile

mobile

logistic

Interestingness and Growth Patterns

Which patterns are the most celebrated ones?

Which are the promising ones?

☐ anorganic, crystalline

☐ organic

    ☐ swarm-based

    ☐ plant-like

    ☐ embryonic

☐ informational

    ☐ logistic, optimizing (leafs)

    ☐ associative (body without organs)

    ☐ learning & behavior

Reaction Diffusion beyond ...

form finding in material

contextualized by C_{5E}

main domain : informational processes

RD as dynamic structure of hidden processes in time

RD as means to create structured randomness,
contextual mixing,
variable local cohesiveness

interesting question: **RD under strong constraints**...

Complexity

productivity based on antagonism

sustainable potential based on lively antagonism

different types of growth on top of complex processes

elementarization

parameter maps as meta-cartography

causality (as a term) erodes

2 Questions...

What are the elements of „cityness" ?

What are the elements of an „architecture" ?

... next topic: Networks.

Fin et Merci!