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Evolution

About Owls flying from Athens to Manhattan

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for PowerPoint only !

Overview

Preliminary Notes

why and how? — relevance of evolutionary thinking
methodology

Natural Evolution

basic concepts — species, selection, fitness
micromechanics of evolution

Generalized Evolution

basic concepts — information, probability
formalization

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Why talking about Evolution?

Evolution is a concept, a model

contextualized by the question...

”What’s coming next?”

or: What is that particular be-coming
that there is this “coming next”?

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What‘s next?

Design (traditional):

starting in a given framework of conventions, intentionally or even consciously solve the task of improving the overall functionality (in the widest sense) of an object

Evolution

starting with a given framework of conventions, blindly solve for yourself the task of becoming a general standard reference thus changing the conventions

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Evolution and Design

There is a problem with the traditional concept of design

It never can be completely determined in advance whether a particular intended change (= planned improvement) is indeed an improvement.

Additionally, there are always side effects

famous example: SMS

Thus, any kind of design comprises also and always blindness to some considerable extent

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Architecture and Natural Evolution

Architectural Design

- produces unique instances = individuals
- obeys to the expectation of types
- raises a self-referentiality through the influence of the life form on architecture

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Relation between Architecture, Evolution

„evolutionary algorithms“

mapping and solving „complicated“ optimization tasks

urban development, or urban evolution?

planned, optimized vs. „blind“, open and abstract

evolution of architecture

future structure, role and performance of architecture

evolutionary architecture

Frazer‘s concept of architecture mimicking nature

architecture :: of evolution, :: of theories of evolution

understanding and utilization of evolutionary processes

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Why talking about Evolution? (II)

The Idea of Change

history of an idea, how to talk about

A Natural Thing?

the challenge of adopting “evolution”

Structures

matter, information, thought

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The Idea of Change: History

Newton (1640): absolute, eternal universe

Dobzhansky (1964)
“Nothing in biology makes sense except in the light of evolution”

What happened in between ?

Earth is older than 6342 years, animals as subject of history

French revolution, exhausting the idea of central mover

19th century science, esp. thermodynamics, large numbers

failure of logical atomism, discovery of relation and historicity

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The Idea of Change: Conceptual Modes

Difference	only between items of the same kind; formal symmetry
Differential Equations	dx/dt, time as a formal embedding structure is assumed to be constant
Sequences	production systems (e.g. grammars)
Emergence	changes in deep structure, e.g. grammar irreversibility generating bundles of time

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The Idea of Change: Contemporary

1940 – 1970, (post-)war

Cybernetical Control, and the failure of its exaggerations

1975 – now

Process as a sequence of modularized cybern. functions

coming up:

Behavior of adaptive devices

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Processes of Change

growth, development, learning, evolution

... they are not independent !

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Example: Form and Growth (very few aspects)

mineralic, growth by accretion, resource problems ...

atomic grid ideological grid

atoms are not distinguishable

modernistic phantasms of norm and status

alibi arguments: industrialization, costs

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Relevance of Growth Patterns

plant-like – controlled by locally constrained, simple reaction diffusion systems

growth patterns are constraining the function space

abstract growth classes are the progenitor and the differential of form

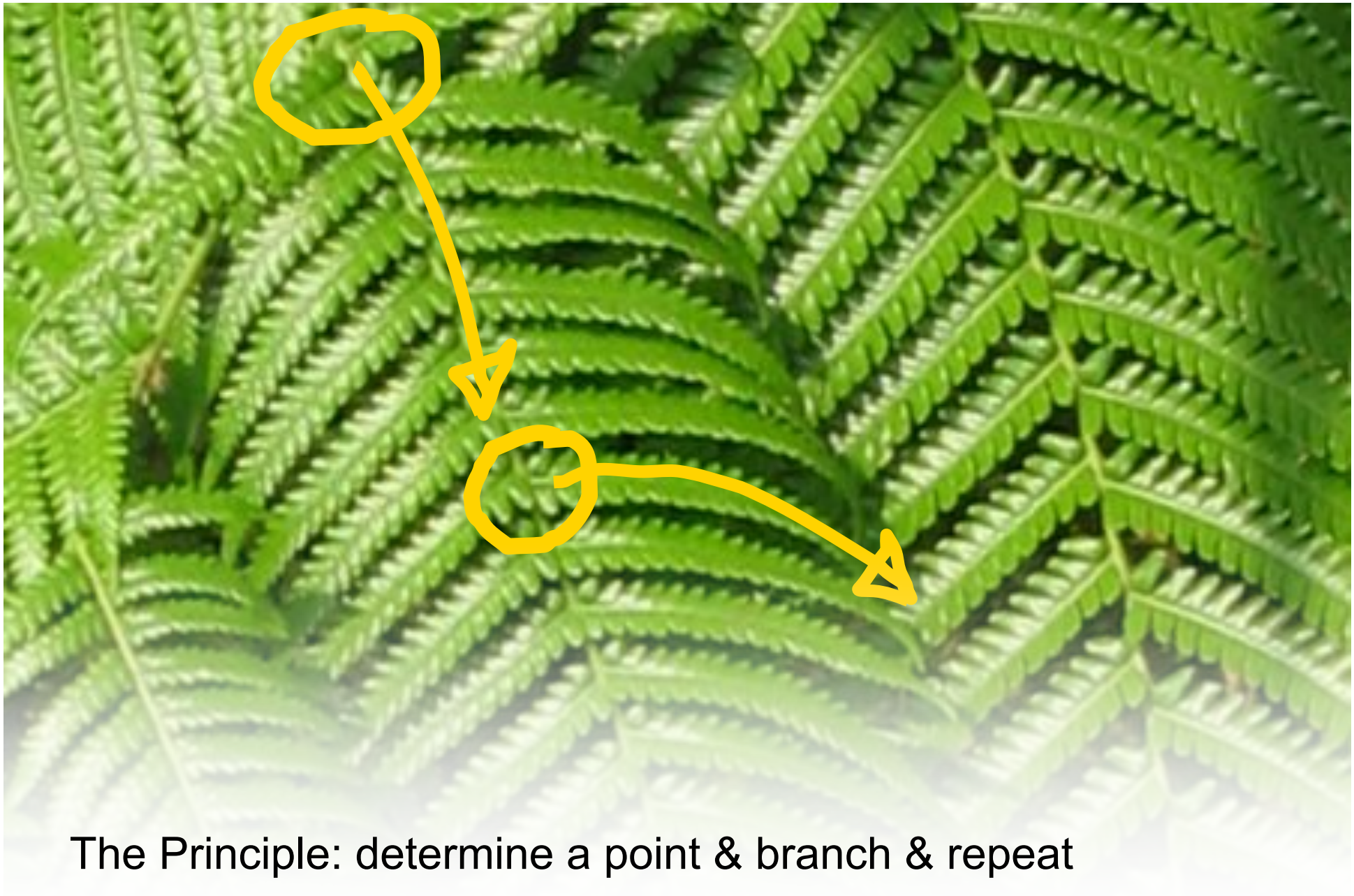
millions of forms derived from the same operator (object::growth class)

growth thus inherits the generation of form

meristemic growth vs. non-meristemic growth

L-Systems, Fractals

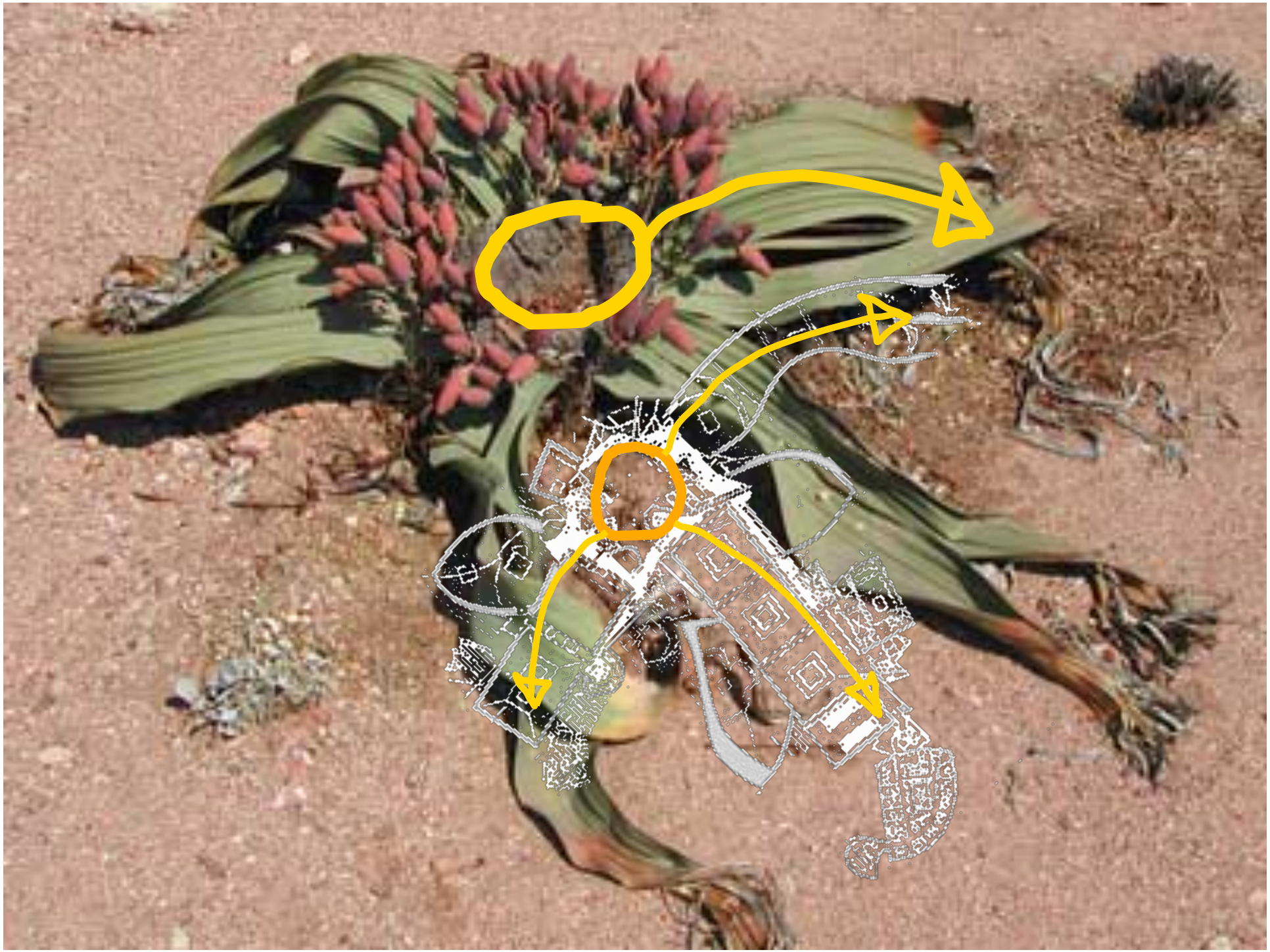
growth, development, evolution, and **memory** are a dense conceptual cluster



The Principle: determine a point & branch & repeat

finding the point: 2-component systems

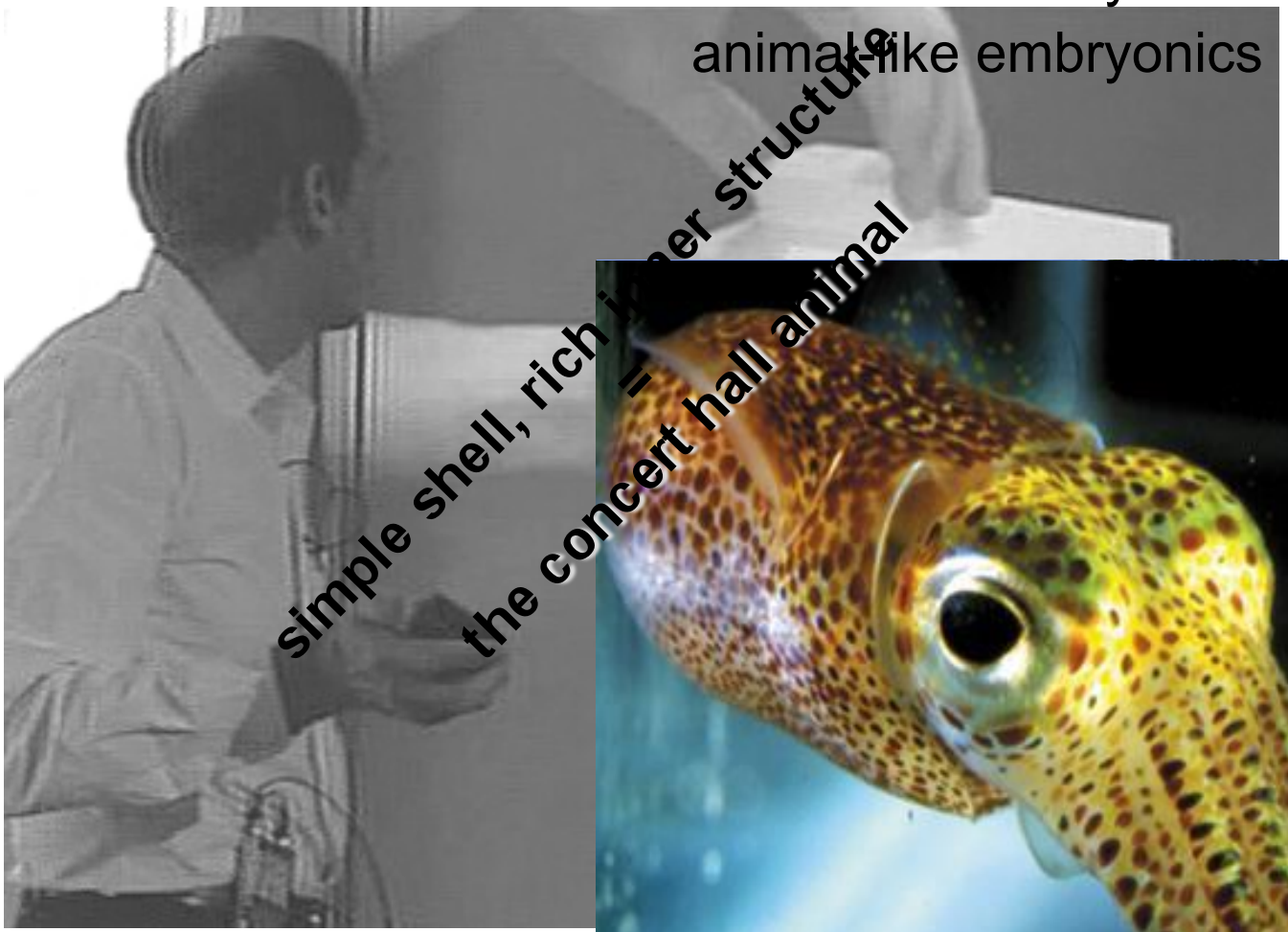
thus suitable for outward directed L-Systems



Non-Fractal Patterns: The Agile House

between epigenetics and the behavioral turn

animal-like embryonics



animal-like embryonics

simple shell, rich inner structure

=

the concert hall animal

targeted melting

apoptosis

movement

skin

anticipation

media facades

the ‚individual‘

the symbolic

buildings *as* media (4th skin)

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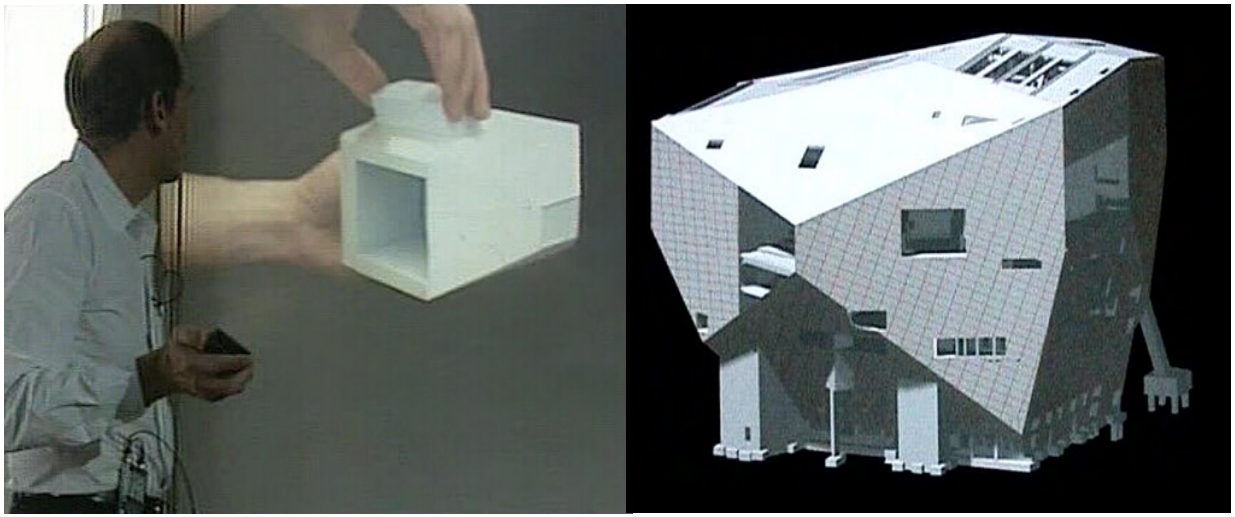
Koohlhaas, the Embryologist?

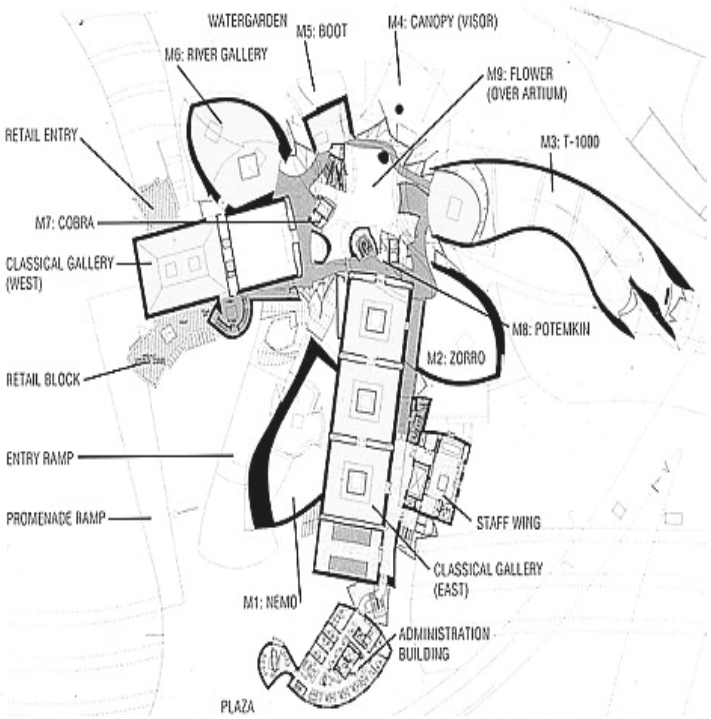
Koohlhaas Constants:
boxes, boxes in boxes, experiences scripts & ramps

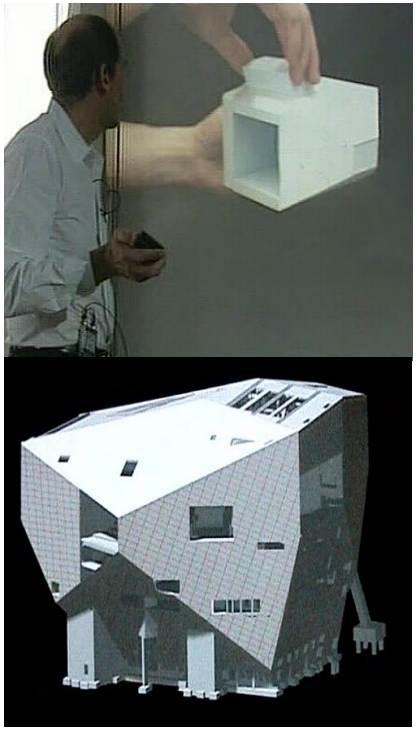


... all of those have direct equivalents in embryology.

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

Models of Growth





plant-like

animal-like

swarm-like

space-time structure

separated

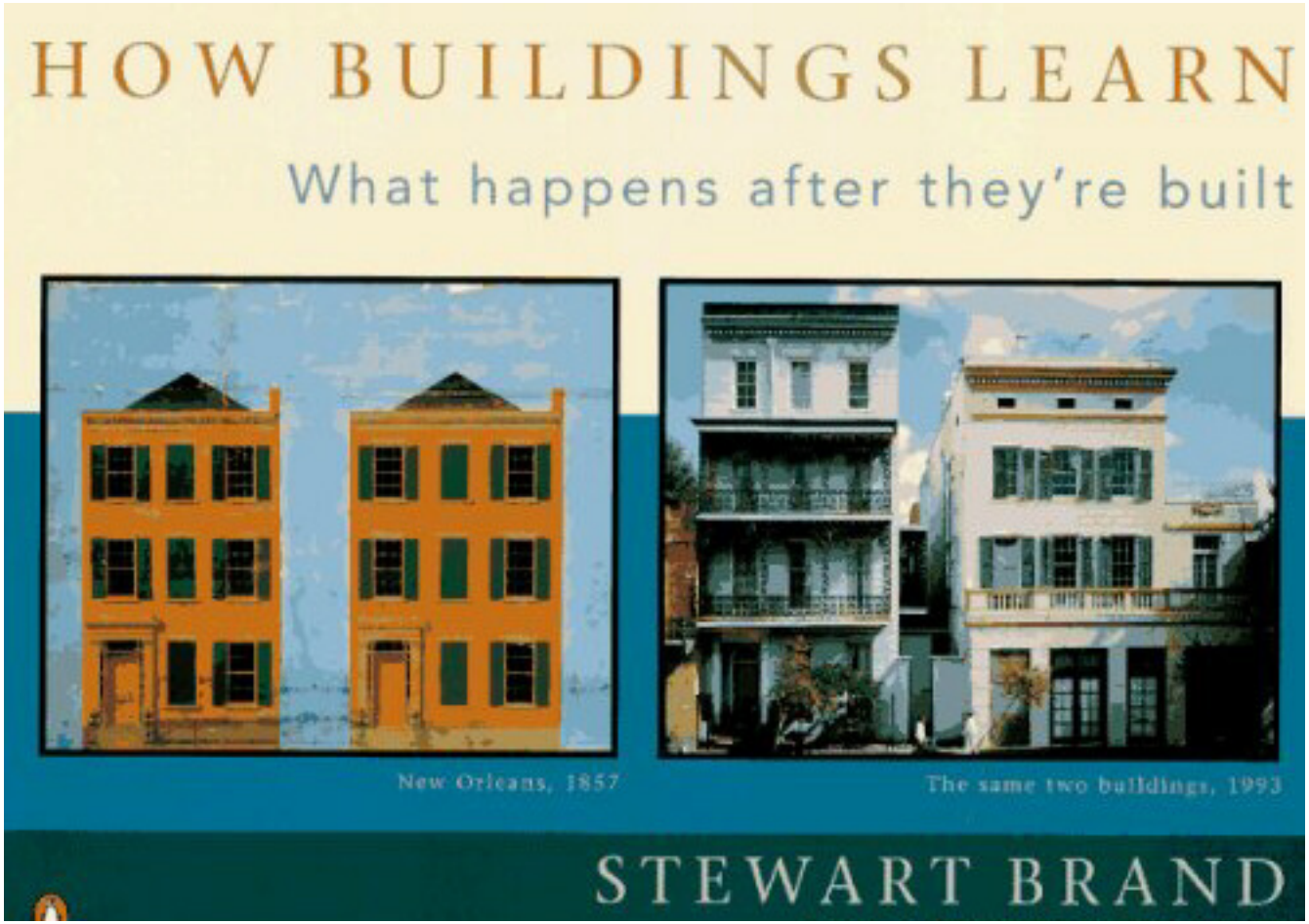
contiguous

emergent

sessile

mobile

logistic


HOW BUILDINGS LEARN
What happens after they're built
New Orleans, 1857
The same two buildings, 1993
STEWART BRAND

Adopting „Evolution“: How?

it is **not** possible in a direct way,

in culture there is no “DNA”, there are no “genes”, etc.

How to transfer “structure” between
incommensurable areas of theory (life)?

⇨ interdisciplinarity

⇨ structure of comparison

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Comparison

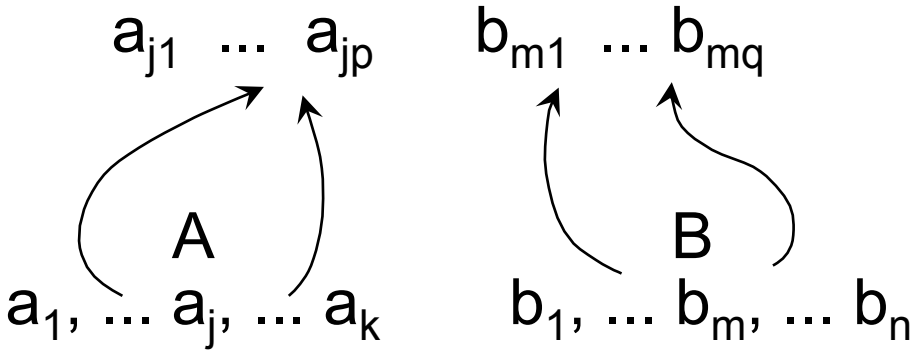
How to compare (theories) A and B?

What‘s going on in a comparison?

A and B are arbitrary !

Math/Stats: $\mathbf{x}_A \longmapsto \mathbf{y}_B$

a mapping; it does not address the actual question, because it already presupposes a particular way of comparing



elementarization is arbitrary

the basic module of comparisons

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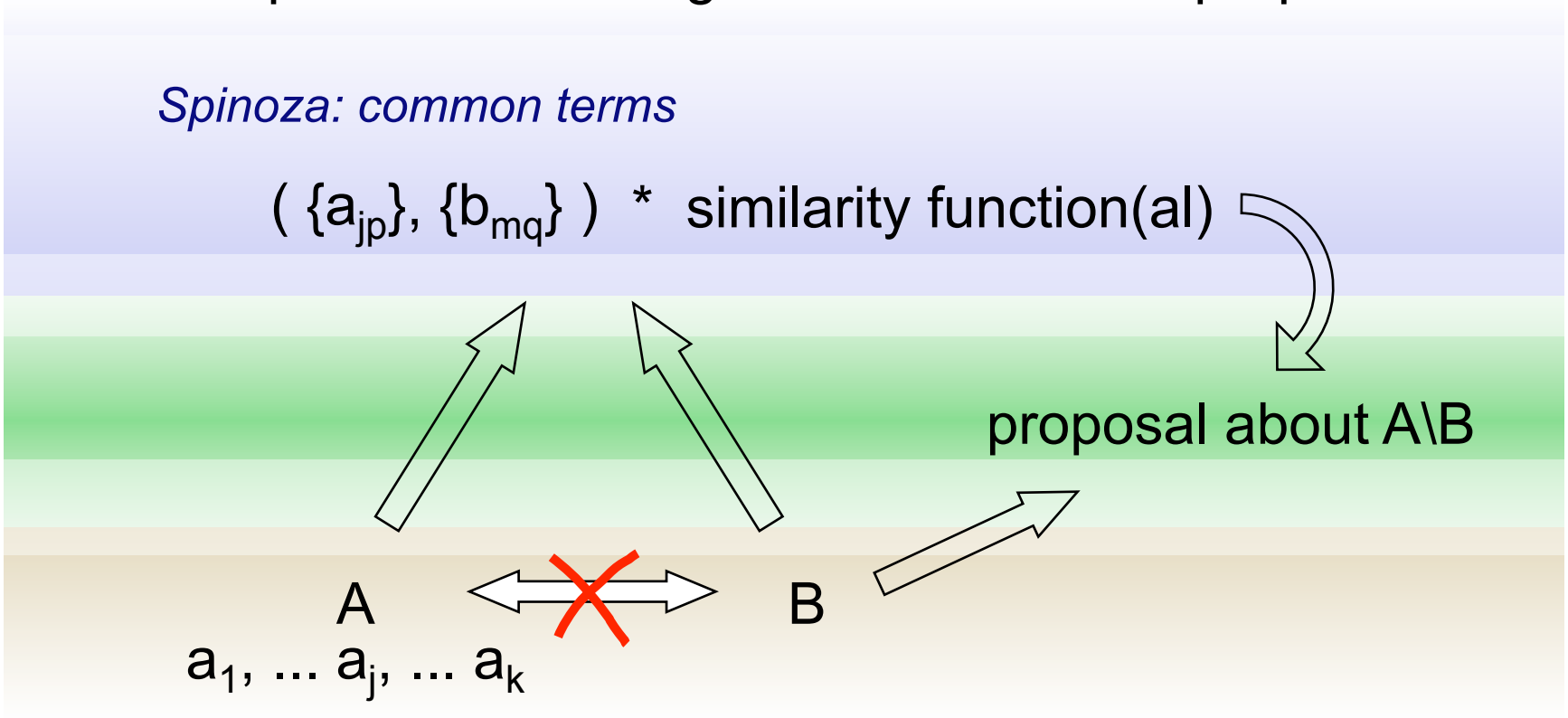
Comparison , Type I (simple)

comparison within a given framework or purpose



It is also the basic structure of: translation, transdisciplinary discourse, competition, interaction

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Natural Evolution

The central issue of thinking about it ...

What are the mechanisms which transform given structures and life forms into new structures and life forms?

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Perspectives on Evolution

Metaphysical Belief-System (before ~1700):
cosmic constancy, no „roll-out“ of a plan, no „evolution“

Mapping Cultural Technology to Nature (1800 ... ~1930)
education (Lamarck), breed selection (Darwin)

Logics and additive Atomism (1930 ... ~1980)
invention of „genes“, genetical cybernetics (Jacob, Monod)

Units of Evolution (1970 ...)
chunks of information in coop-etition games (Maynard-Smith)

Evolving World: the Gaia-principle (1870, 1980...)
everything is connected (Peirce, Margulis)

Genuine & singular Mechanism for Novelty (1990 ...)
a general „principle“ to establish novel configurations

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Natural Evolution

The basic annoying question ...

Is there a {trend} in evolution ?

rules, laws, goal

or in (architectural) history?

YES! but if, which one? sort of non-trendy trend?

NO! why then is there this difference between stones and brains at all ?

Is it possible to „create“ evolution ?

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Approaching the Annoyance

The solution: Conceive it as a Mechanism

Mechanism...	rule-based
	local rules, no master designer
	open outcomes
	linking causality and information
„systems“ of mechanisms	not determined
	machinic

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Mechanizing Evolution

write a formula!

Dogma of Darwinistic Theories of Evolution

Evolution = Variation + Heredity + Selection

don‘t take the „+“ literally here !!!

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The Dogma of Darwinism

Evolution = Variation + Heredity + Selection

Variation

randomness in mutations
double set of genes
recombination of genes in sexual reproduction

Heredity

genes, and only genes (genotype inheritance)

Selection

survival of the fittest
only on the level of the phenotype

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Implicit Assumptions

species

clearly separated, clearly defined

compatibility = identity

the individual is atom & subject of evolution

heredity

only on the level of genes

genes are completely „private“

selection

„selection“

the „system“ is the selecting instance

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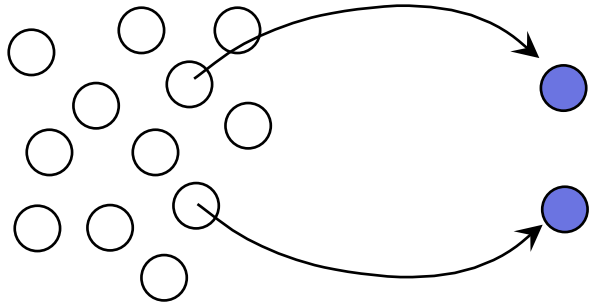
The Inverse of Selection ...

variants

selection

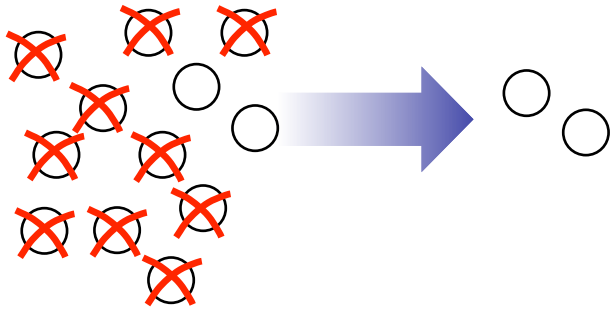


needs an external instance, directed force

which is not available in evolutionary processes

selection as a „left-over“ effect

limited memory



it is more a de-selection!

is a by-pass effect of

- modeling, learning
- building classes — cognition
- limited memory — processes
- metabolism — material turn-over
- „forgetting“ — brain, data

... results again in „selection“

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Species

concept originally from baroque science

attempt to create a navigable cartography for an overwhelming manifold

a mode of speech

binary, digitized, idealized

What is the problem with the species concept ?

as a part of traditional evolutionary reasoning,
it requires exact separability, **1 species = 1 set of genes**,
incommensurable to any other

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Species, Quasi-species, Population

a „Gene“ is a probabilistic set (a „cloud“) of variants
and fuzzy relations

the concept „species“ can NOT be defined anymore by „crisp genes“..., as if genes would „represent“ the (readable blueprint) of the organism

examples: „strong“ symbiotic coupling, endo-symbionts, viruses, horizontal gene transfer

instead, we have to define „species“ in terms of information and risk ! ... (later, in the formal section)

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Fitness

the core of the operationalization of evolutionary theory
intended to make evolutionary processes measurable

DEF: number of offsprings in secondary filial generation (F2)

problems

1. the style of operationalization is too restrictive, even arbitrary (evolution as natural breeding!)

2. there are very different strategies (r,K), thus fitness is not applicable to compare different species

3. the problems 1+2 given the central role of fitness in theory of evolution

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Fitness: hidden structures

basic assumptions

- there is a clear preference order
  for contributions of properties to overall fitness
- fitness function is well-defined (no fuzziness)
- properties map smoothly to overall fitness
- mapping of properties to overall fitness
  is stable

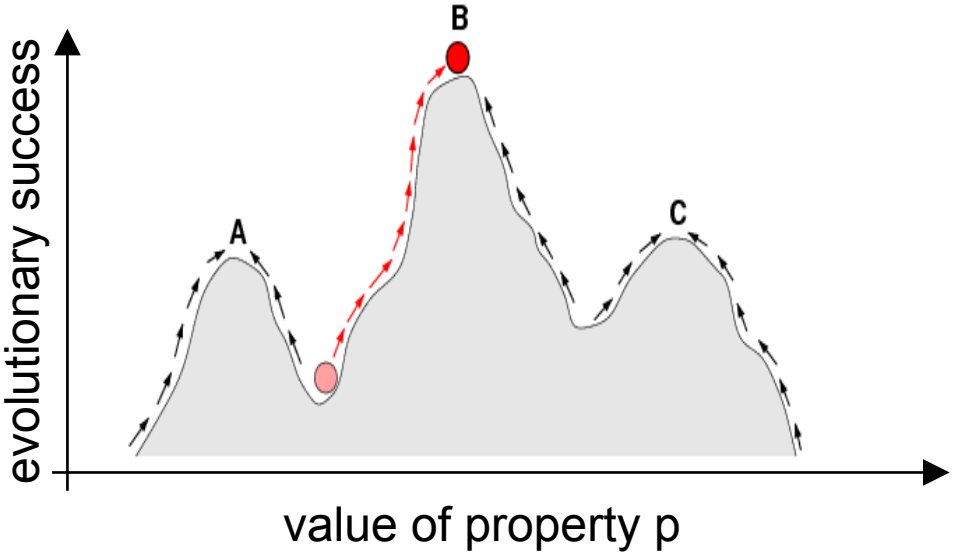
... in reality, they are all severely violated...

today, fitness is often converted into
energy consumption and time budgets

does not solve the problems

Fitness Landscapes: A Model

relating variation of properties to evolutionary success

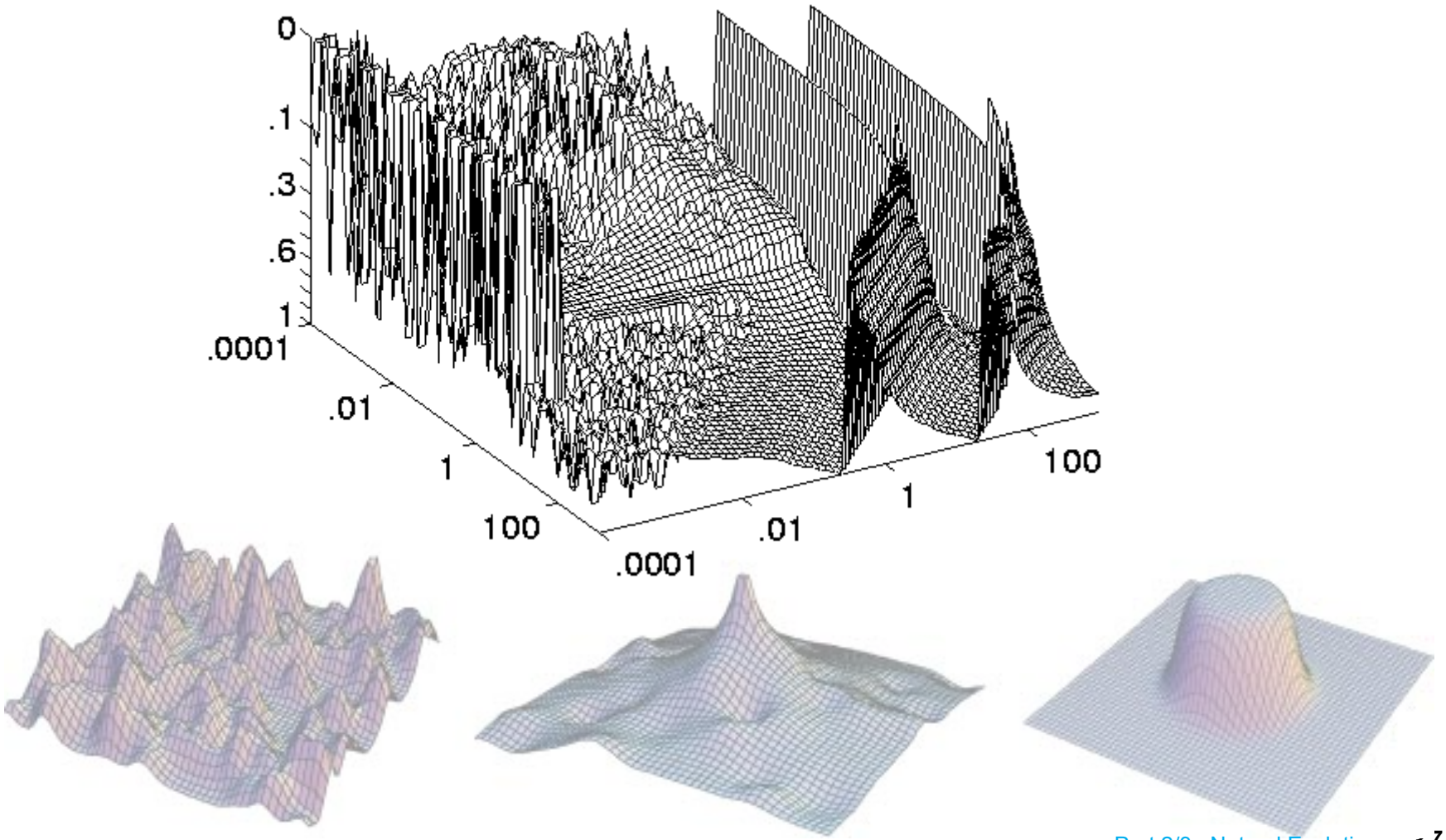


high-dimensional parameter space, n > 30‘000

abstract and virtual „landscape“, linking all (!) genes and their combinations to the selective value of the integrated organism

dependent on all of other species

Fitness Landscapes:
Possibility and Directions of Change

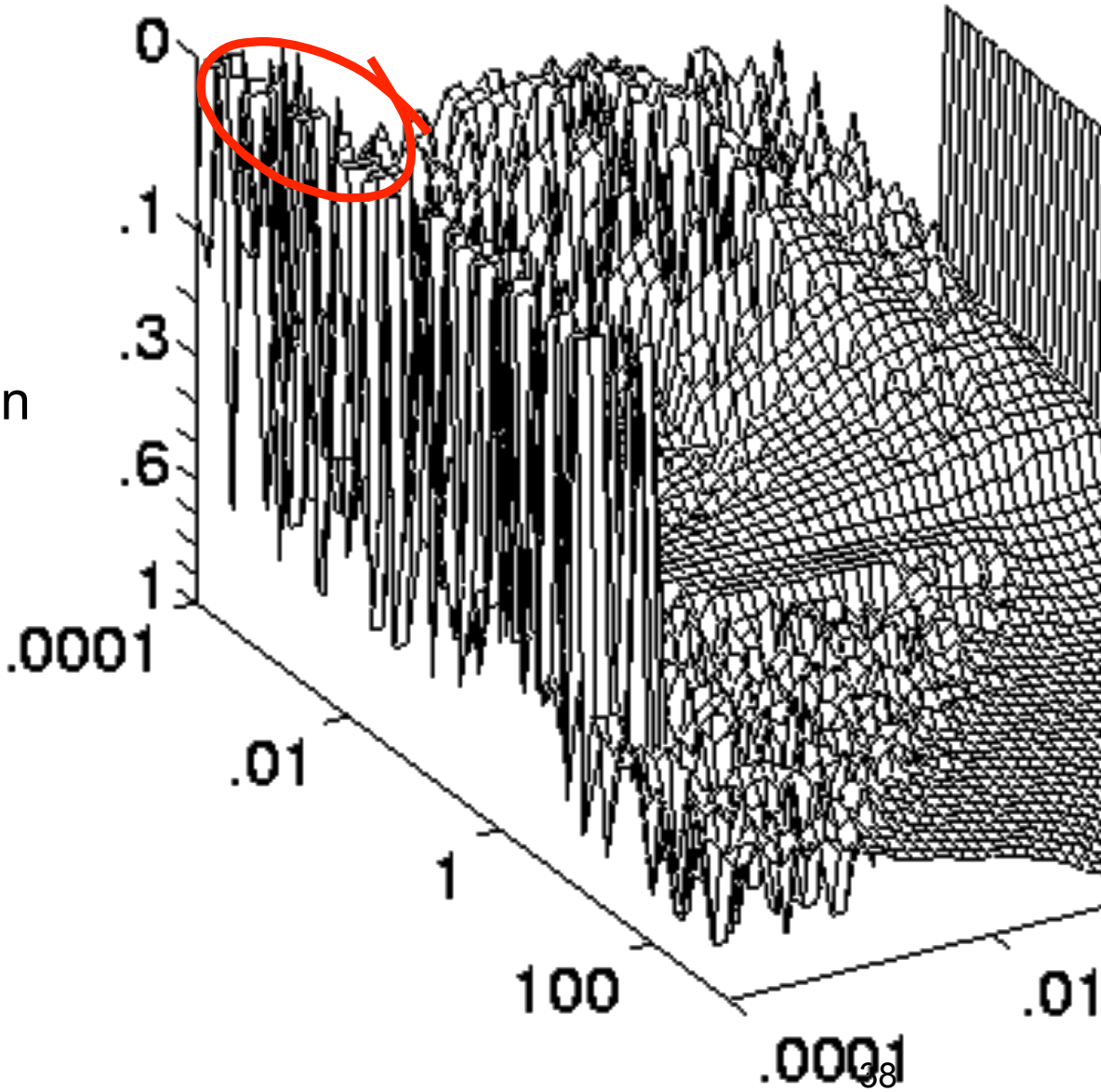


Your Fitness Landscape: How to deal with it

gene coupling, nested compartments, pleiotropy or complexity cause ruggedness of the FL

capability for further evolution can be achieved only by redundancy in encoding and functional structures:

e.g. diploidy, gene doubling, multi-cellularity, organs



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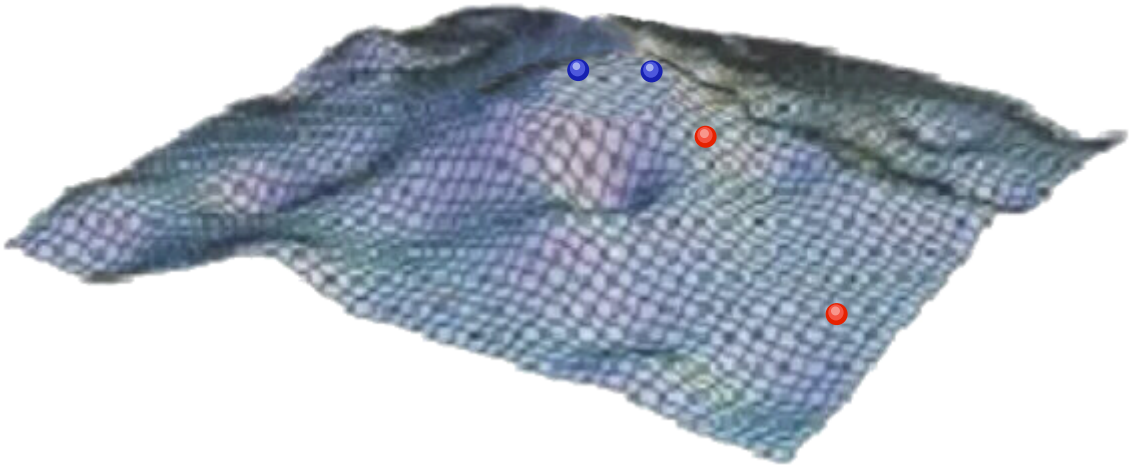
Fitness Landscapes: changing fate

What are the most sustaining and powerful moves concerning fitness landscapes ?



flattening the fitness landscape

becoming more independent from the environment

more variants will be possible, evolution will be „faster“

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Fitness Landscapes: Moves, Moving

What are the most sustaining and powerful moves concerning fitness landscapes ?

generalist
breeding
eco-active
evo-smartness

1. smoothing and flattening the own fitness landscape
2. coupling the fitness landscape of others to the own
3. distorting and rugging the fitness landscape of others
4. anticipating the effects of acting on coupled fitness landscapes

these conclusions you will not find in any textbook.

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Fitness Landscapes: Conclusions

friendly Co-Evolution instead of dangerous competition, also known as „social system“

smooth FL allow for fast development of variants

smooth FL are inhabited by generalists

subject of evolution is not the organism, nor the gene, it is neither competition:

The Subject of Evolution is the Fitness Landscape
(= capability to evolve)

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Evolution: Trendy Stuff?

CLEARLY YES!

There is a {trend} in any evolution ...

on the level of evolutionary strategies we find a trend

more general structures, capability for generality

greater independence from more basic factors

better anticipation

invention of information, semiosis, symbols, rule-systems, simulation

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Fitness: a much better definition

given the fact, that acting onto the fitness landscape
is the *most effective* way to survive ...

and fitness is given as an abstract parameter space ...

we can – most importantly – define fitness **independent** from reproductive success and also more abstract:

fitness := capability to deal with the risk of vanishing
as an informational configuration

Autonomous reproductive success is now visible as just one particular possibility to be „evolutionarily fit“.

Reproductive success results in „not vanishing“, but the notion of the persistence of informational configuration is much more general

Genes, Species, Population

„Gene“ is a historical concept, which first existed as a hypothesis, it was considered the smallest „unit“

„Genes“ do not exist as evenly arranged pieces, they are split, scattered, often they are overlapping on the same pieces of DNA,

„Genes“ also do not exist as logically sound pieces. There are regulatory „genes“, repairing genes, and genes need a very complicated and scattered apparatus in order to „exert“ their function

a „Gene“ is a probabilistic phenomenon, consisting of clouds of material variants and probabilistic relations between materially encoded functions

Conditions for Progress

If selection is a „left-over“ effect, and
variation is a random process of small steps, then...

(1) How is it possible that new traits appear ?

(2) How is it possible that new traits appear
without loosing the existing achievements?

What can we say about the Micromechanics of Evolution?

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Micromechanics of Evolution

Given a particular morphological structure, or informational configuration (behavior)...

new processes and functions appear during evolution.

Since functions are usually complex, non-trivial, we need:

changes of functional roles

in biological evolution, before any morphological change there is always a change in behavior

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Micromechanics of Evolution

changes of **functional roles**

Double-function (⇨ change of function)

a structure (or behavior) can (in most cases)
serve more than one usage or purpose

primary mandibular joint, feathers, brains, language

without this dynamics,
there is NO evolution at all,
neither of new structures nor
of dynamic traits

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Larger Steps: Hypercycles

empirical findings

regulated scale from symbiosis to parasitism

the „cell“ is not a homogenic invention of a singular descent

any living entity on any scale is deeply embedded

formal considerations

additive random mutations of singularized genotypes
would have taken take too long

due to thermodyn. instability of large molecular assemblies
even life itself would not have developed by additive chance

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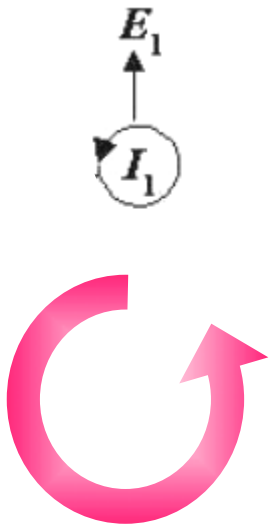
Larger Steps: Hypercycles



I = auto-katalytic, self-maintaining, autonomous entity, informationally encoded mechanism

E = e-dukt, not a „pro-duct“, more kind of „waste“

stage 1: feeding accidentially on E(n)

stage 2: E(n) becomes essential for I (k), which thus becomes dependent from E(n)

stage 3: the hypercycle builds a stable compartment or hull

effect: large, already working pieces of causally effective information are assembled into a causal circle of co-dependent functions

Eigen built a molecular hypercycle machine in the biochem lab

Micromechanics of Evolution =
Logics of Invention and Innovation

Double-function + Left-over of lucky Variants

Hypercycles

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Conceptualizing Generalized Evolution

Start field

Evolution = Variation + Heredity + Selection

Hypercycles

Double-function

How could we rewrite this?

1. Living systems contain codes and mechanisms
2. Living systems live in populations

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Intermediate Summary – old style definitions.

Evolution = Variation + Heredity + Selection

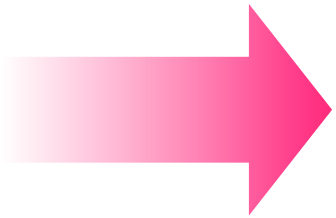
terminological and logical difficulties,
terms are not separated

Species = mating produces fertile offsprings in F2

mixing up the factual and the potential,
species membership is assumed to be binary I/0

Fitness = # offsprings in secondary filial generation (F2)

equal to „survival of the survivor“, circular or empty definition



structural deficits:
everything is defined on a material level (19th c.)

Conceptual Intermezzo

Causality

Information

Probabilism

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Causality

Aristotle distinguished 4 aspects

causa materialis
formalis
efficiens „physical“ force
finalis

these aspects can not be reduced to each other !

They are *dimensions* of causality.

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Information

What „*is*“ it? When do we use it?

What‘s the difference to causality?

small experiment ...

information is only „visible“ retrospectively, subsequent to interpretation.

expecting information only possible by encodings, and as a virtual

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Dimensionality of Information

We could distinguish 3 dimensions

form

effectiveness

extension

form	bits (like in language), as a whole (like an image) from which we have to extract parts
effectiveness	reliability or certainty
extension	strictness of its encoding.

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Information & Causality

Causality is a binary relation: a bit of it does not make sense

The concept of „information“ is not compatible to causality.

Information : area of reversibility

Causality : area of ir-reversibility (bodily actions)

From information to causality via de-coherence

„information“ is the language game about potential decisions

From causality to information via probabilism

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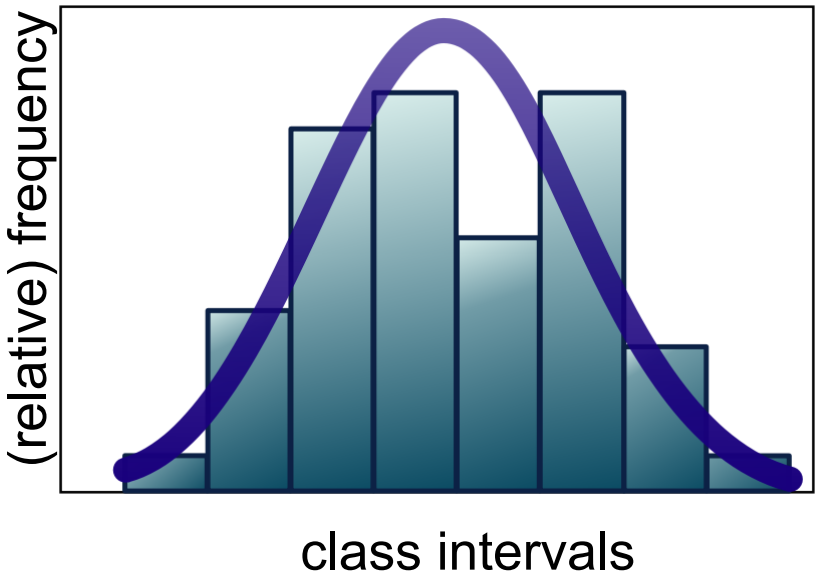
Probabilism



any observed item is conceived as a sample of a distribution

items are transformed into „random variables“

any observable is conceived as a distribution of a random variable

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The Random Gene

a „Gene“ is a uniquely defined sequence on the DNA

empirically refuted by modern genetics!!

a „Gene“ is a probabilistic set (a „cloud“) of variants and fuzzy relations for their translation

general definition of „gene“ which can be used transdisciplinary

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Informationalized Evolution

Keyterms

probability, distributions, risk, opportunities,
anticipative modeling, memory,
well-founded expectations, non-dichotomous scales
information (capacity, processing),
associativity, networks

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Rewriting the classical Formula

evolution = variation + heredity + selection

heredity = long-term memory

depositing lasting, replicable structures, „genes“

selection = short-term memory

forgetting is just selection, „stability“ of frequency

variation = synchronous randomness

physico-chemical
externalized-factual
internalized-self-organized

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Towards a New Formula

abstract (general) model components of evolution:

- (at least) **2 different memories**
  distinguished by time span

  (and, optionally, also time resolution)

- randomness (which is inevitable anyway)

now changing perspective... **not**: what ***is*** evolution?

but: for ***which configurations*** will evolution take place?

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Evolution: Memory + Duration

given the relationship

$$Mem(d_1) + Mem(d_2) \circledR \text{ evolution}, \quad d_1 \text{ «» } d_2$$

or, incl randomness, more compressed and more general:

$$M(d_i, [r_k])$$

The combination (synchronic union) of at least 2 memories with different duration and, optionally, of different temporal resolution, modified by an operator for synchronous randomness, results in an evolution

we now can ask NEW questions:

- conditions for, and consequences of d_1/d_2 ?
- physical / algorithmic instances of memories M ?
- realization of randomness & its interaction with M ?

Organism

a non-biological, informational definition

according to the definition of evolution as a particularly configured process of at least two different synchronically active memories, we define „organisms“ also probabilistically as an ensemble of memory configurations

$$\dot{E}_{i^3 2} e^{*} M(d_i, [r_k]) \quad \circledR \quad \text{evolution}$$

$$\text{organism} := (\mathcal{M} \mid m_i)$$

an organism is a device which “is” and which can maintain an assemblage of different kinds of memories, each of different duration and resolution, which build a continuum, a probabilistic memory configuration $\mathcal{M}$

Any embedding „evolutionary“ process picks at least two different „memories“ from that ensemble. If the durations are sufficiently different, that organism will be a part of evolution

Species, re-visited

a „Gene“ is a probabilistic set (a „cloud“) of variants and fuzzy relations

now, we can define the concept of „species“
in terms of information and risk

$$\left(\mathcal{M}_i, \mathcal{M}_k\right)$$

.

the limes of the probability for a unification of two different sets of probabilistic memory con-figurations (e.g. organisms) approaches 0 under conditions of potential interaction

most important, this definition does NOT use „**identity**“,
but „**difference**“ as a logical basis!
(Thus we avoid any sort of divine or romantic idealism)

Quasi - Species

according to probabilistically defined „species“,
we get for quasi-species : population = superset of memories

$$(\grave{E}\ \acute{a}\mathcal{M})$$

a population of organisms, where organism = probabilistic memory configuration $\mathcal{M}_k$

$\mathcal{D}$ is the density of the probabilistic distributions of the parameters m determining the superset of memory configurations $\mathcal{M}$.
The limes of the probability for a unification of two different sets of memory configurations is >0 for any quasi-species.

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Summary

Trans-Darwinian Theory of Evolution

$$\sum_{i>2} e^{*}\ M(d_i, [r_k]) \ \Rightarrow\ \text{evolution}$$

$$\text{organism} := (\mathcal{M} \mid m_i)$$

$$\text{species} := \lim_{n\to\infty} \text{prob}\left(\bigcup (\mathcal{M}_i, \mathcal{M}_k)\right)_n \to 0$$

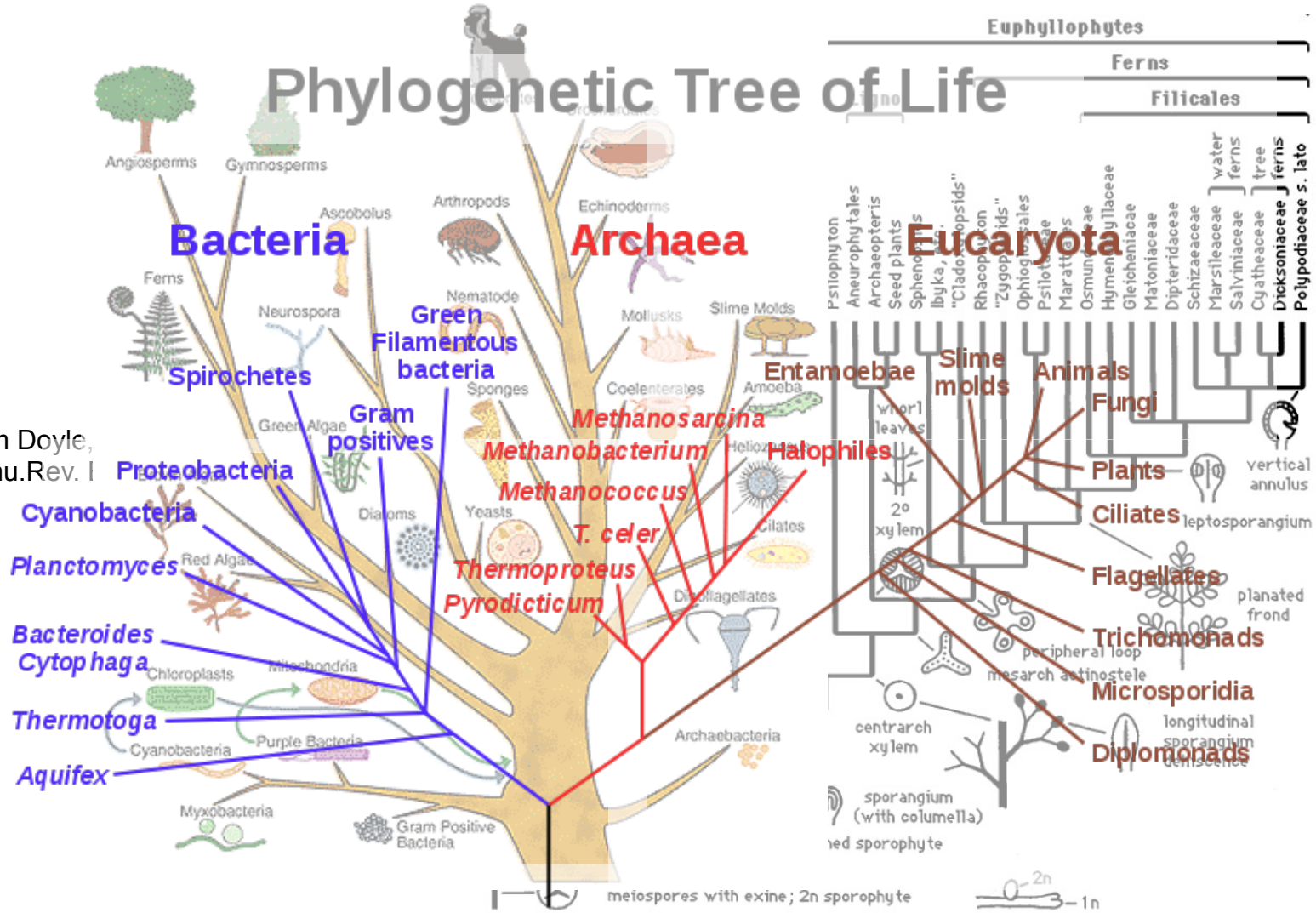
$$\text{quasi-species} := \lim \text{prob}\left(\bigcup \alpha\mathcal{M}\right) > 0$$

$$\text{where } \mathcal{M} = \mathcal{D}\left(\prod f(m_i)\right)$$

$$\text{population} := \{\text{quasi-species}\}$$

$$\text{fitness} := \text{prob}\left((f: \text{prob}(\{Q\}) \to 0) = 0\right) > 0$$

The Tree of Evolution



from Doyle, Annu.Rev. I

Figure 1 Synopsis of relationships among bryophytes and "lower" vascular plants found in morphological and molecular analyses [based primarily on the work of several others (83, 95, 102)], with sketches illustrating important synapomorphies in vegetative morphology, stem anatomy, and sporangia. "Bryo," bryophytes; Ligno, lignophytes.

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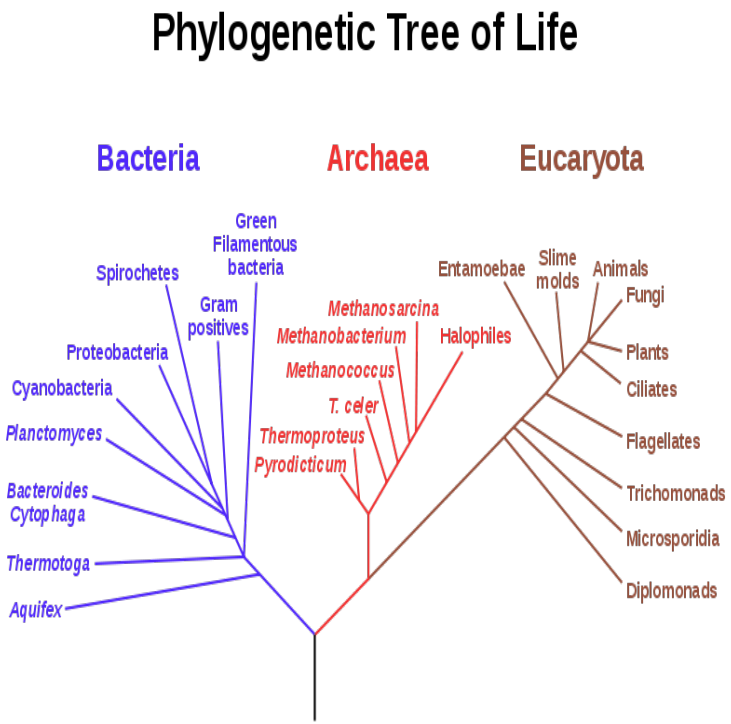
The Tree of Evolution is not a Tree!

nor a bush



Main Problems

only genes are considered as „memory“,
no account of systemic aspects

exactitude as self-hypnosis
(no horizontal transfer of information e.g. genes)

gene sequences of presence are taken as a mirror of a complex history

Evolution = a probabilistic individuation of populations of memories

this allows much better scaling of arguments

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Concluding Remarks

Research on Evolution in Architecture ...

- now we can address adaptive architecture in a new way

- concerns urban processes, questions of style,
  prospective history of technoscience,
  transformations of life forms

- identifying the realization of „memories“
  and its dynamics

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