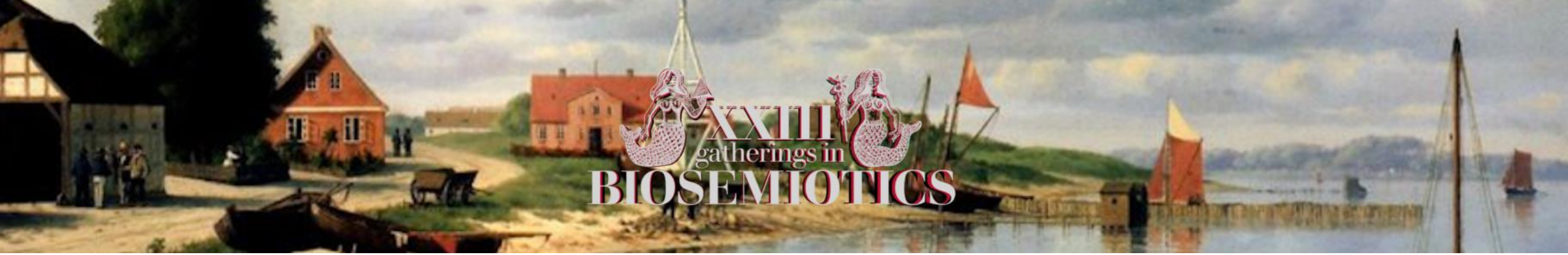


31 July to **4 August** 2023 - Copenhagen

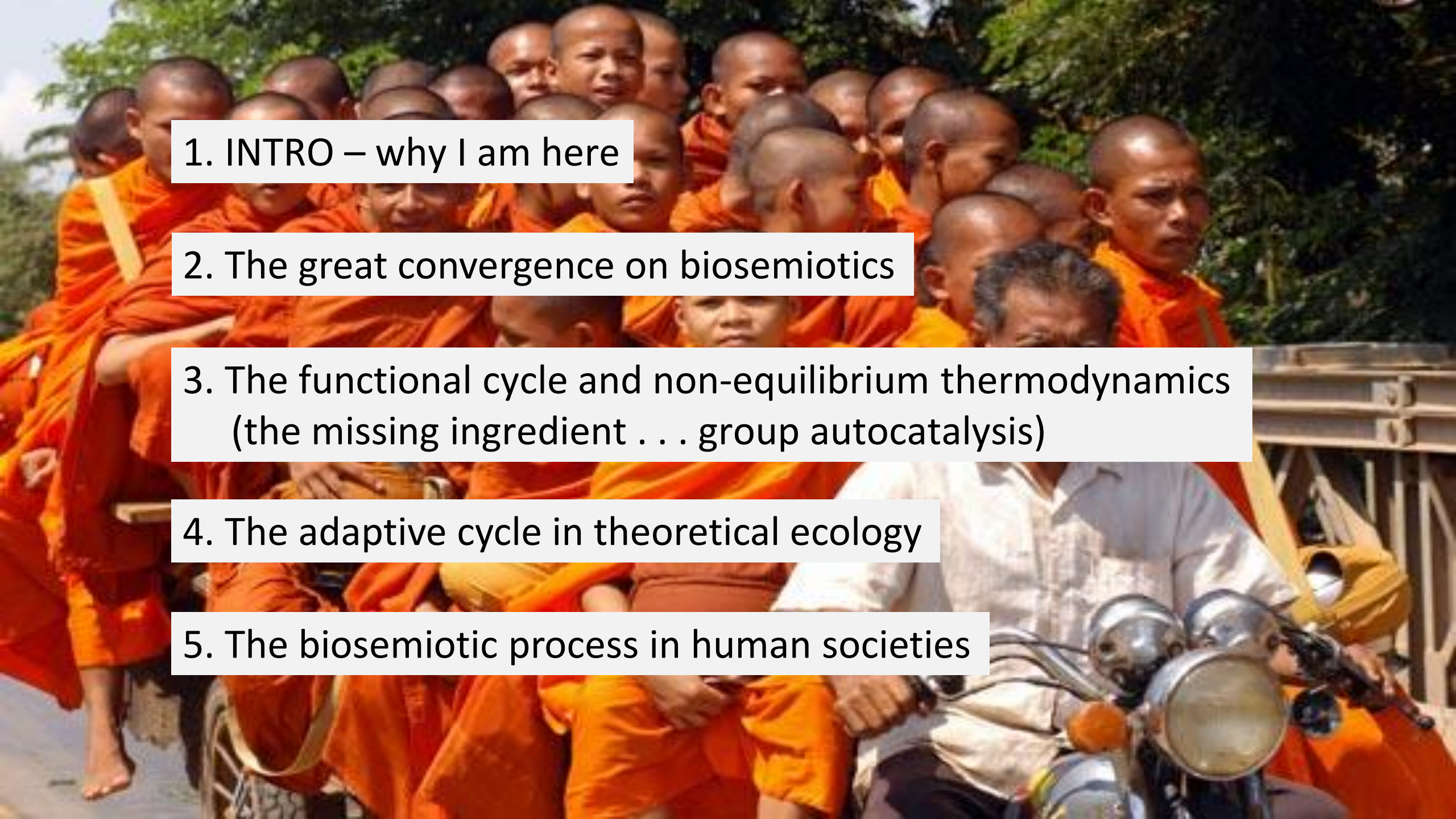
The biosemiotic process: How to reproduce and adapt the identity of social systems by combining emotions and language

Mario GIAMPIETRO

ICREA

icta Institute of Environmental Science and Technology • UAB
Research Group on Integrated Assessment

UAB
Universitat Autònoma de Barcelona



1. INTRO – why I am here

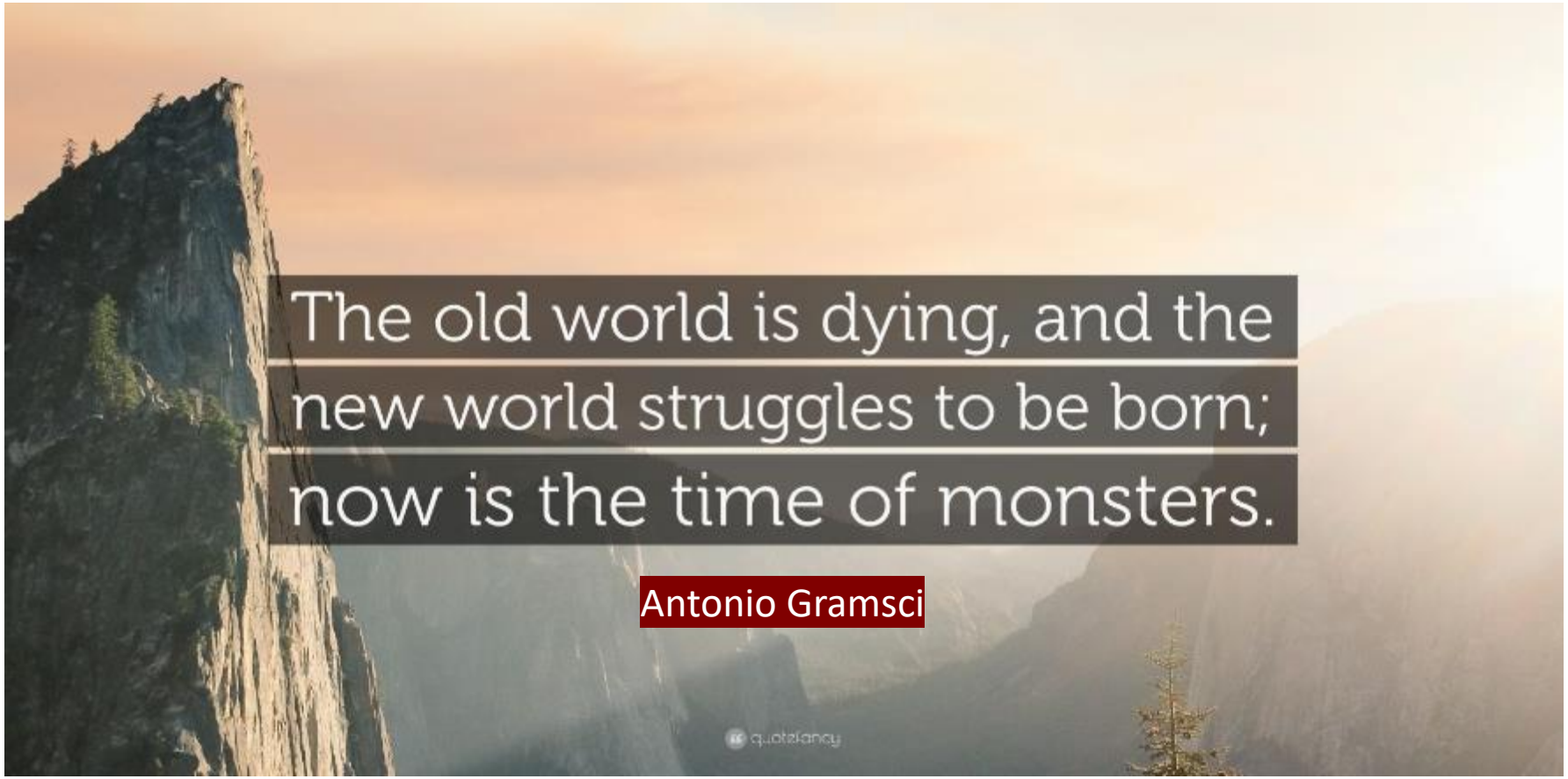
2. The great convergence on biosemiotics

3. The functional cycle and non-equilibrium thermodynamics (the missing ingredient . . . group autocatalysis)

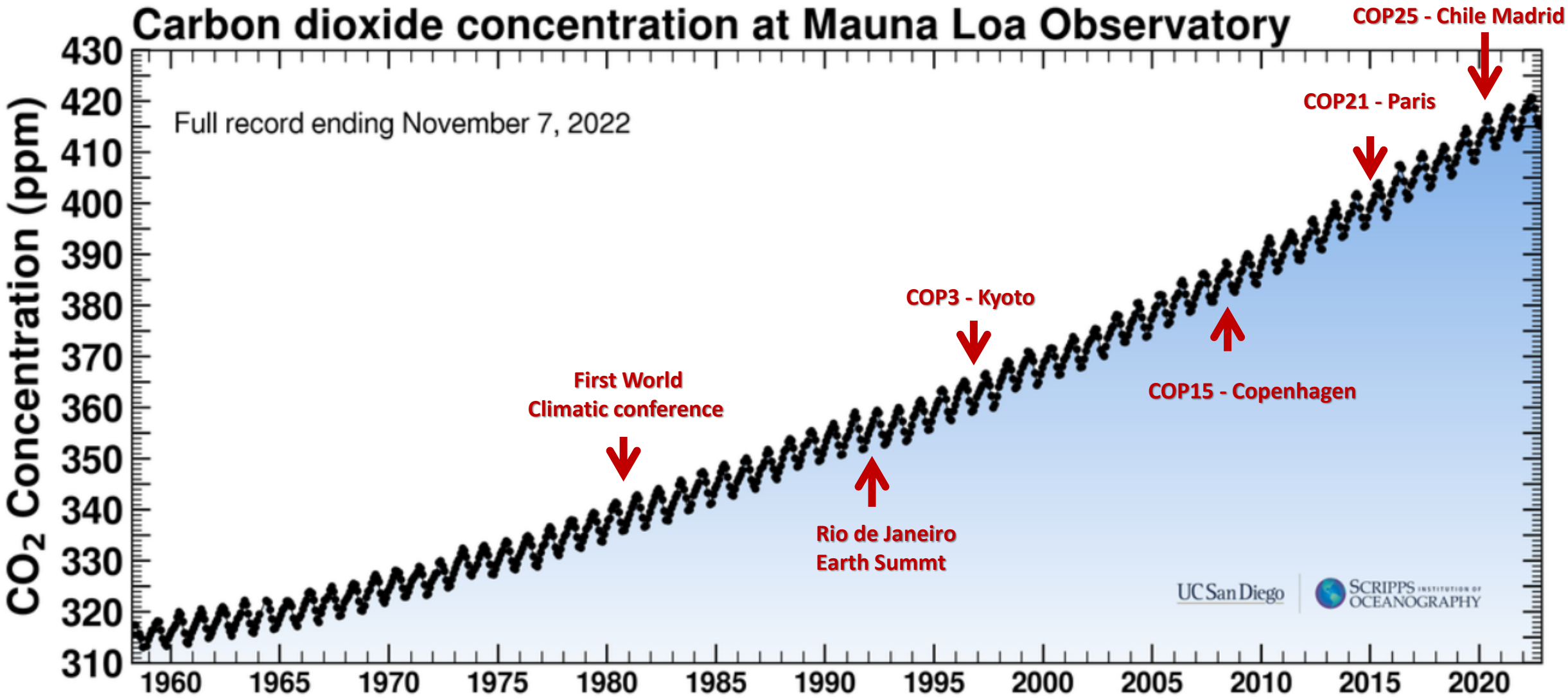
4. The adaptive cycle in theoretical ecology

5. The biosemiotic process in human societies

The sustainability crisis consists precisely in the fact that . . .



1. INTRO – why I am here



https://keelingcurve.ucsd.edu/ full record – 1960-2022

Earth System Research Laboratories
Global Monitoring Laboratory

The narrative of N. Luhmann

Validated kn ge based on narratives nomies referring to t

?

COMMUNICATIONS

REPRESENT

Validating knowledge

institutions

knowledge claims

rules/controls

data/models

IDENTITY

NOTIONAL SIDE

INTERPRETATION — *epistemic cut* — *epistemic cut* — INTERPRETATION

TANGIBLE SIDE

IDENTITY

POLITICAL POWER

GUIDING ACTION

MONITORING AND CONTROL

INTERACTIONS

ACT

Using knowledge

Shared e giving justifica the chosen y

?

LEGITIMIZING

UPDATING

Sc nical im ies

MORAL POWER

affective interactions

feelings

fears/dreams

archetypes

GRO NTITY

?

EME G ECO MS

?

outside

Metabolic pattern of biophysical interactions

Social Practices

inside

Psychic Structure made of instances of humans feeling the effect of affective interactions

Orthodox definition of **Biosemiotics**

SIGNS INTERPETATION IN LIVING SYSTEMS

Can we use a complementing definition?
i.e. about the **Biosemiotic process**

The process used by Complex Adaptive Systems (including living systems and human societies) to generate, reproduce, and adapt their identity during their evolution

2. The great convergence on biosemiotics

Herbert Simon
Complexity

represent
RECIPES
PROCESSES
act

IDENTITY

Complex Adaptive Systems

NOTIONAL

REPRESENT

INTERPRETATION

IDENTITY
Functional cycle
IDENTITY

INTERPRETATION

ACT

TANGIBLE

Ilya Prigogine
Non-equilibrium thermodynamics

represent
DNA
METABOLISM
act

IDENTITY

Howard T. Odum
Theoretical Ecology

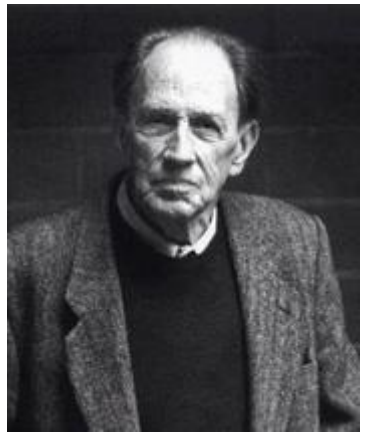
IDENTITY

INFORMED AUTOCATALYTIC LOOPS

SENDING MESSAGES TO THEMSELVES INTO THE FUTURE . . .

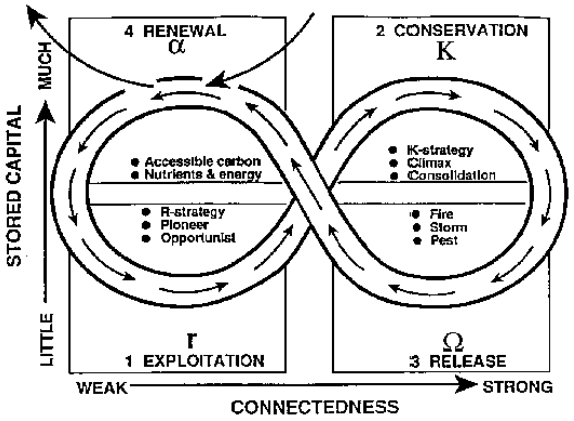
IDENTITY

Ramon Margalef
Theoretical Ecology



IDENTITY

C.S. “Buzz” Holling
The Adaptive Cycle



Complex Adaptive Systems

NAMED

NOTIONAL

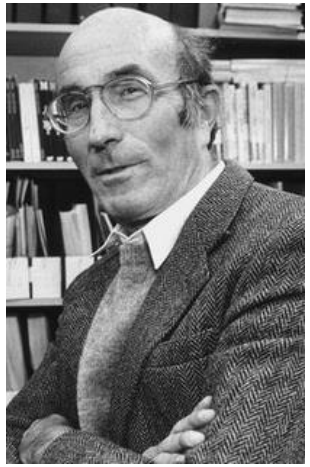
before *after*

ACT

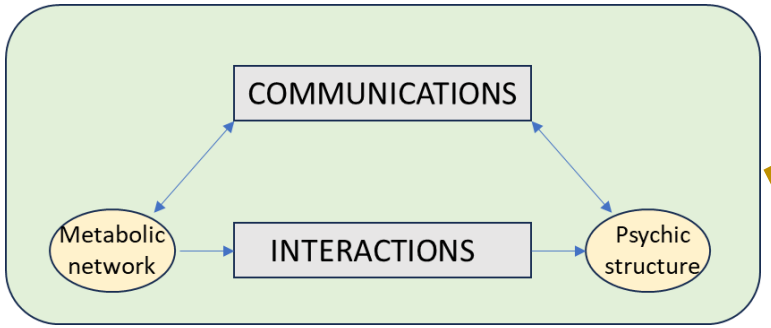
TANGIBLE

TAO

eternal unfolding present



Niklas Luhmann
Social System Theory



IDENTITY

2. The great convergence on biosemiotics

3. The functional cycle and non-equilibrium thermodynamics (the missing ingredient . . . group autocatalysis)

Living systems must remain different from their environment in order to remain alive
Therefore, the study of life belongs to the domain of non-equilibrium thermodynamics

Erwin Schroedinger

NOTIONAL **TANGIBLE**

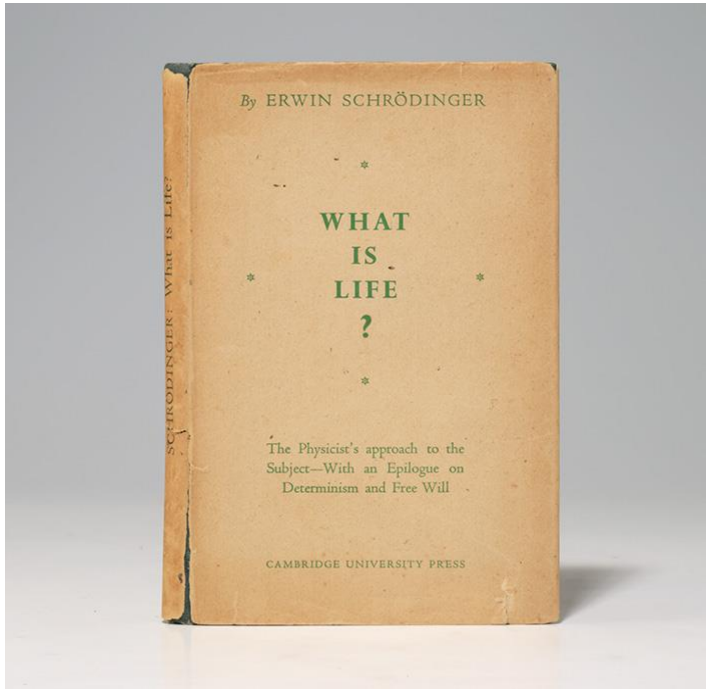
1. Types (equivalence classes) VS Instances

2. From being to becoming **PARTS vs WHOLE**

3. Structural coupling of Dissipative Systems

IDENTITY ←→ ADMISSIBLE ENVIRONMENT (UMWELT)

+dSi ←→ -dSe



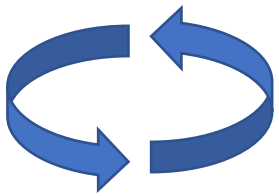
Identity of a dissipative system

notional

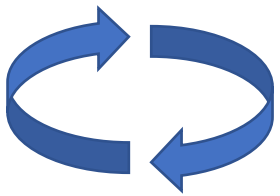
Type (expected)

It depends on boundary conditions
random events initiating conditions
PHYSICAL LAWS

Anti-clockwise



Clockwise



DIGITAL

EPISTEMIC CUT

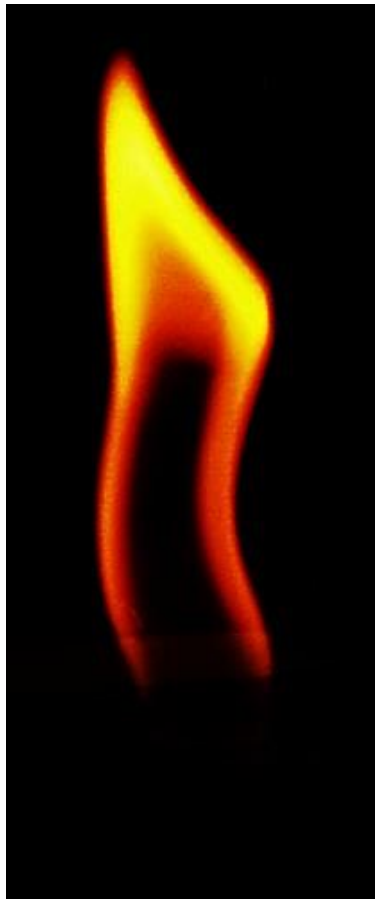
tangible

Instance (established)

Locked-in → path-dependent identity

Keep record of 1 bite of information
as long as it remains “alive” . . .

ANALOGIC



A flame

Dissipative structure whose identity
is different from the environment
but **fully determined by physical laws**
(initiating and boundary conditions)

They can become something different while remaining the same!

Bacteria

Complex adaptive systems **obey physical laws**,
HOWEVER
their identity is **generated by semiotic controls***
that prevent physical laws from fully determining
their structural and functional features

***Semiotic freedom = communication based on codes,**
whose meaning depend on purposes and memories

THE PHYSICAL LAW:
STRUCTUAL COUPLING
(the origin of UMWELT)

Supply of a flux of negative entropy

$-dS_e$

Internal production of positive entropy

dS_i

Processes taking place outside the semiotic control

Processes taking place under semiotic control

encoding how to produc entails heavy assumptions nature of the process place in the environm mining -dSe

MARKOVIAN BLANKET

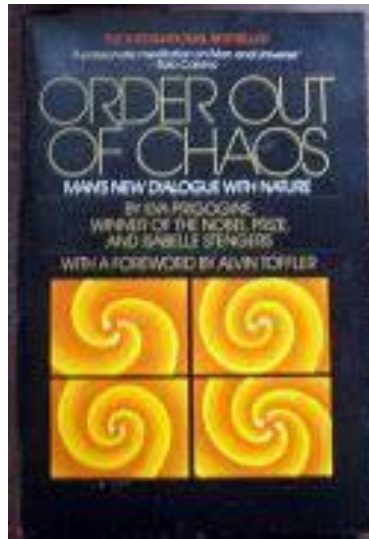
ble
adients

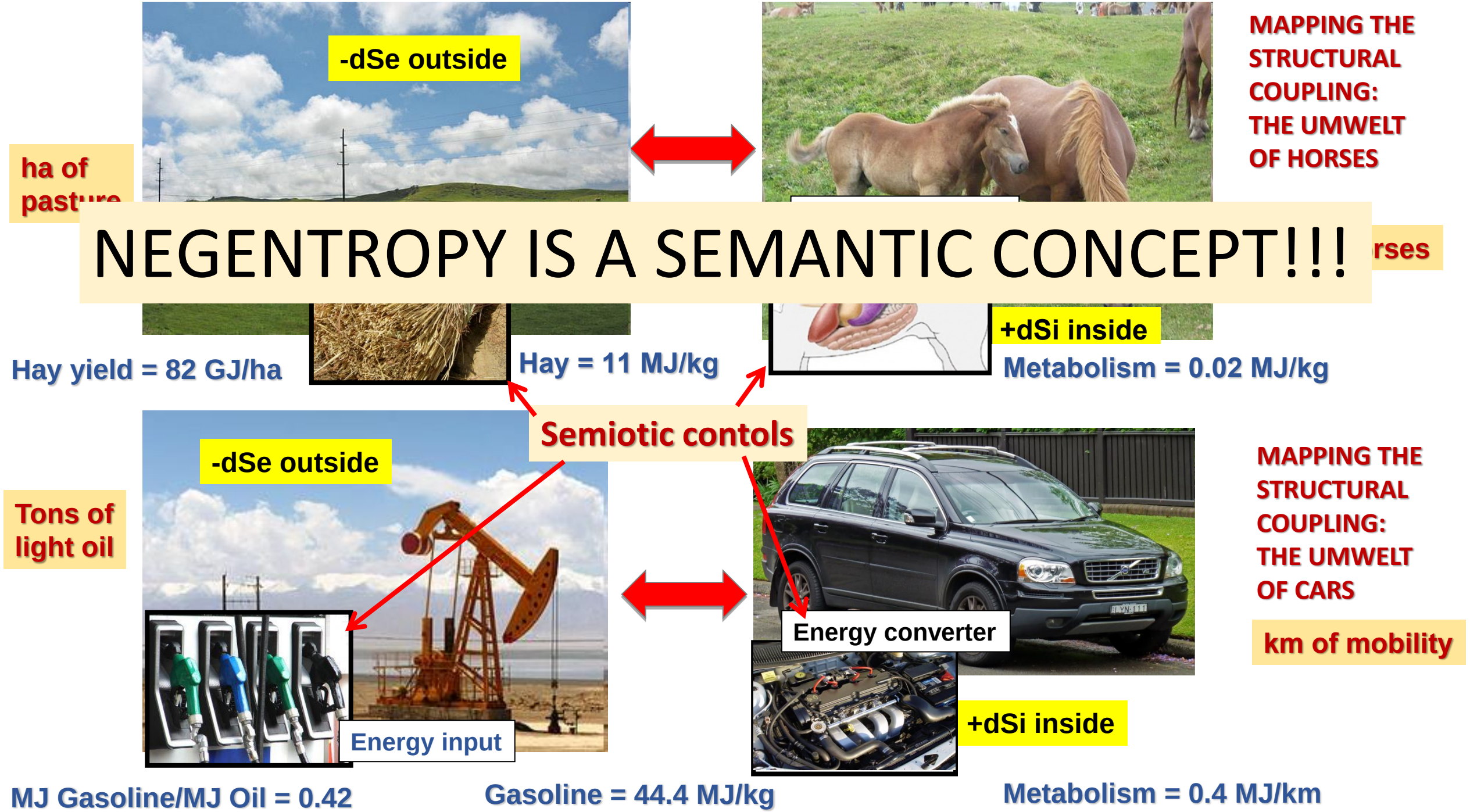
Dissipative Structure

for a dissipative structure that is producing +dSi the environment is a system producing -dSe

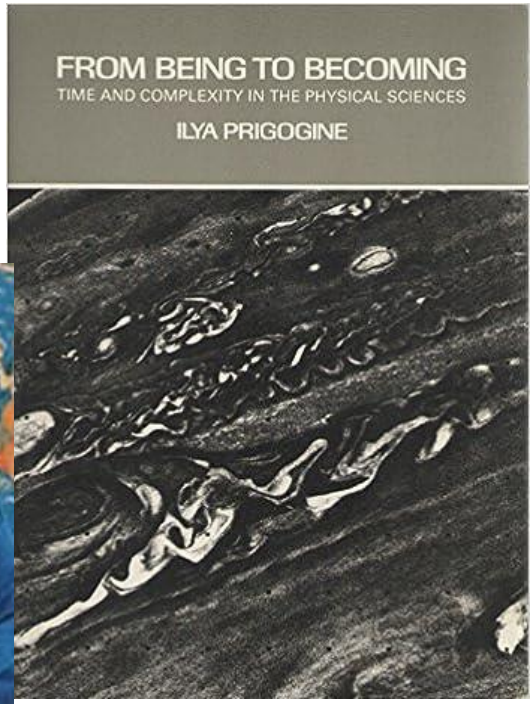
A living system is a Dissipative System

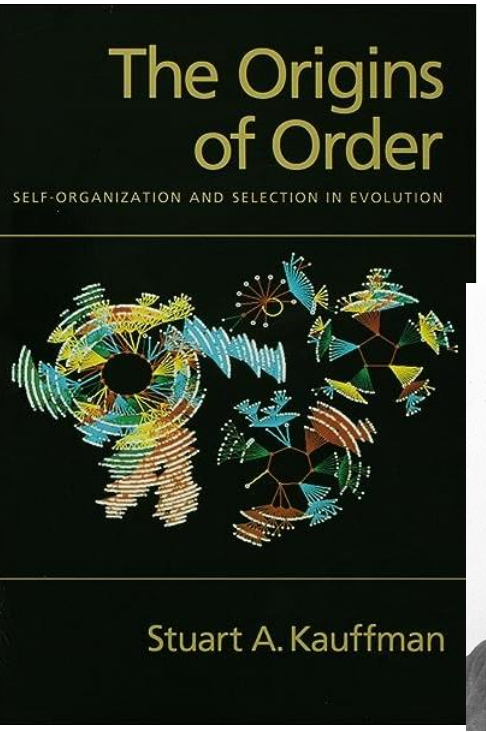
Ilya Prigogine




-dSe outside
MAPPING THE STRUCTURAL COUPLING: THE UMWELT OF HORSES
ha of pasture
NEGENTROPY IS A SEMANTIC CONCEPT!!!
rses
+dSi inside
Hay yield = 82 GJ/ha
Hay = 11 MJ/kg
Metabolism = 0.02 MJ/kg
Semiotic contols
-dSe outside
Tons of light oil
MAPPING THE STRUCTURAL COUPLING: THE UMWELT OF CARS
km of mobility
Energy converter
Energy input
+dSi inside
MJ Gasoline/MJ Oil = 0.42
Gasoline = 44.4 MJ/kg
Metabolism = 0.4 MJ/km

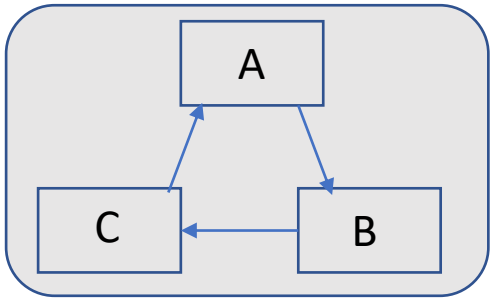
The magic of group autocatalysis

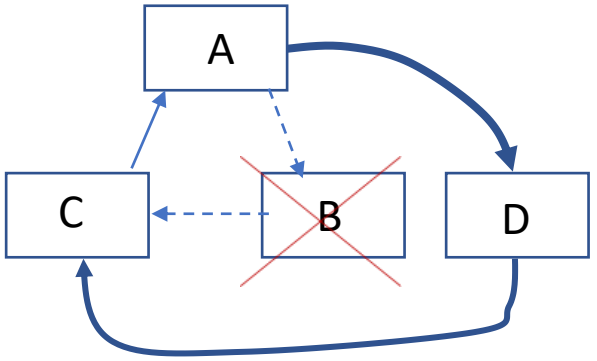


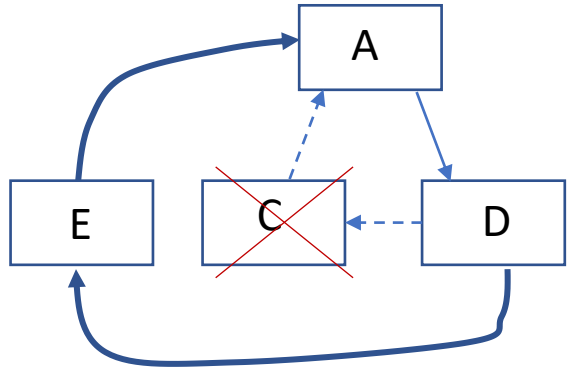


Handling “the epistemic cut” (across levels and scales) in terms of “mutual” and “direct” information a.k.a. DOWNWARD and UPWARD causation

Evolution of a group autocatalytic loop, which can remain the same while becoming something else . . .

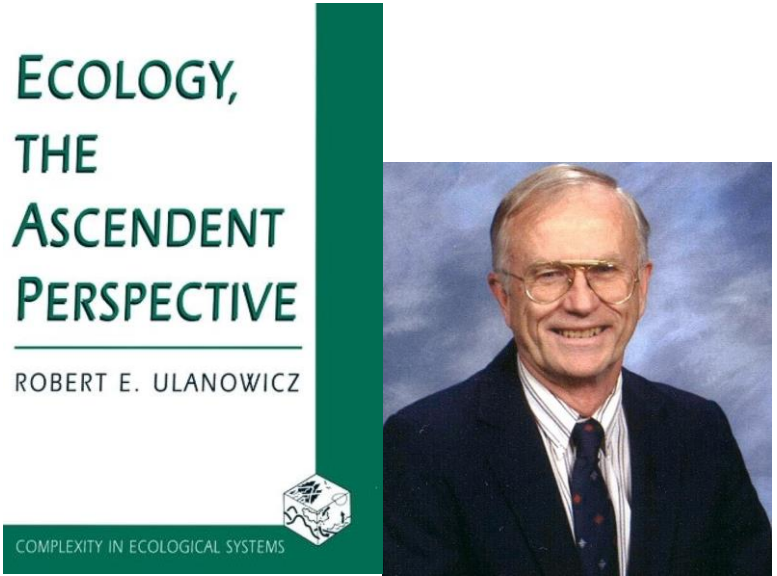




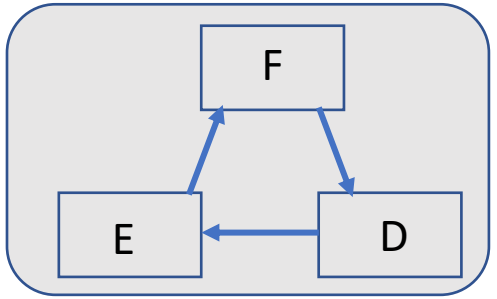


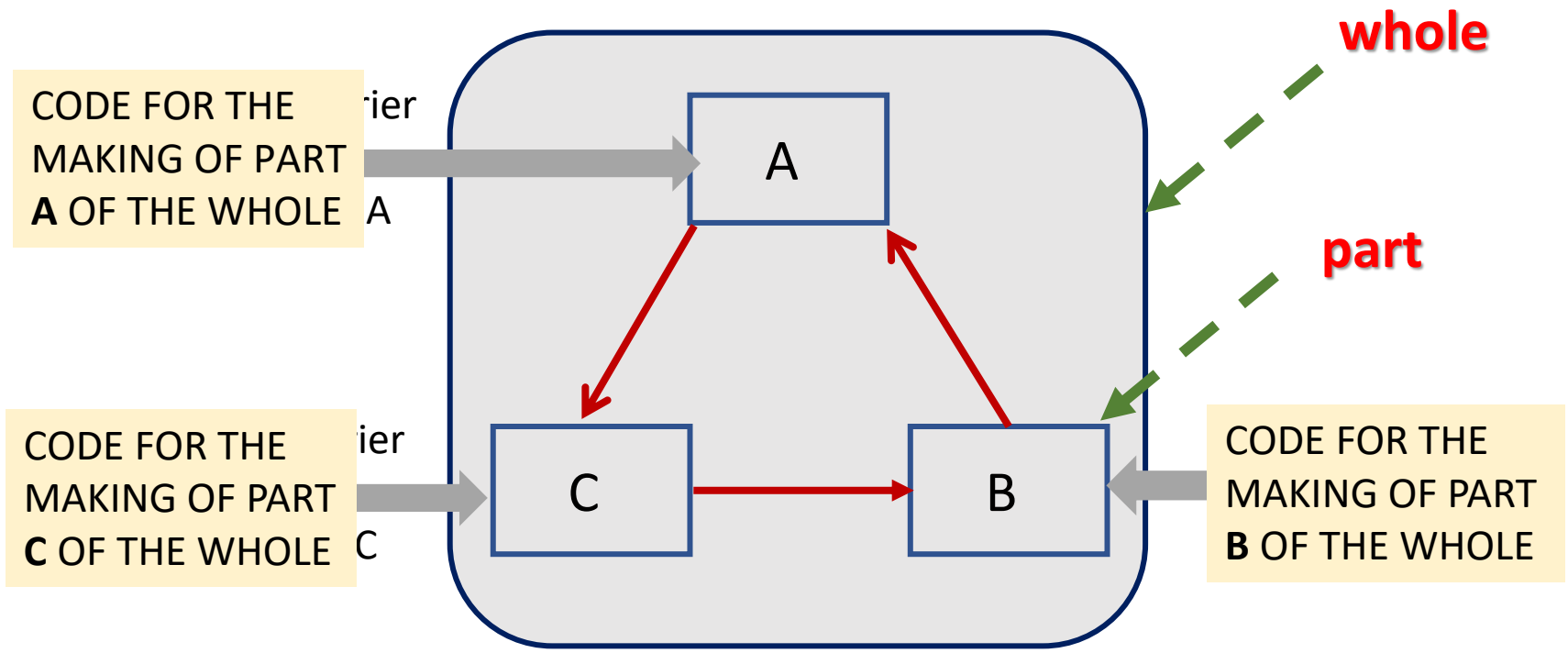
What is remaining the same?

. . .

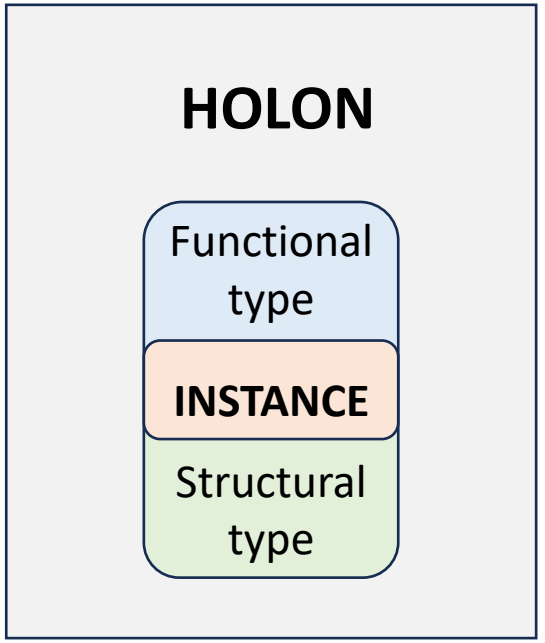


SAME "WHOLE"
DIFFERENT "PARTS"





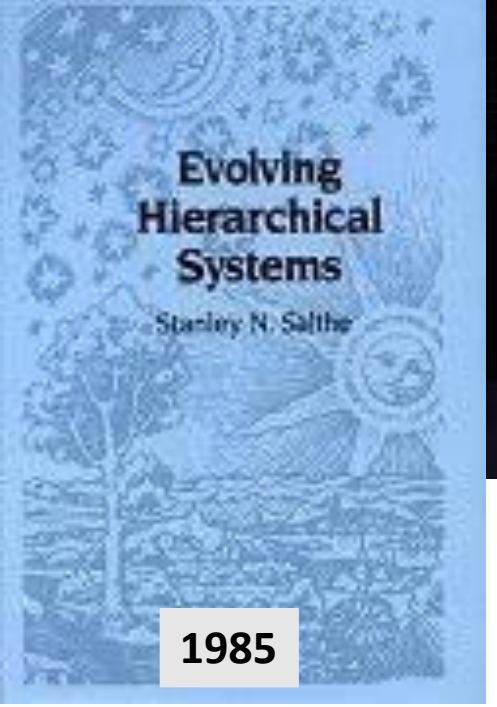
A hypothetical 3-component group autocatalytic loop



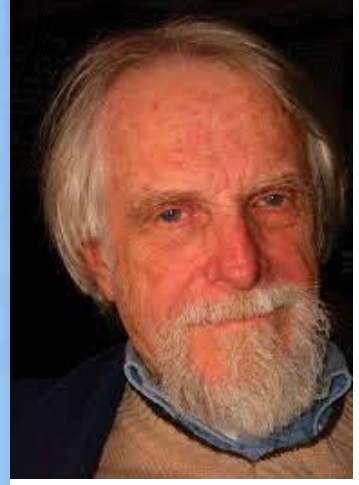
As soon as you establish a "part/whole"* relation the information carriers used to make the parts become ***codes*** for the making of the whole

EMERGENT PROPERTY = **what gave meaning to the parts**

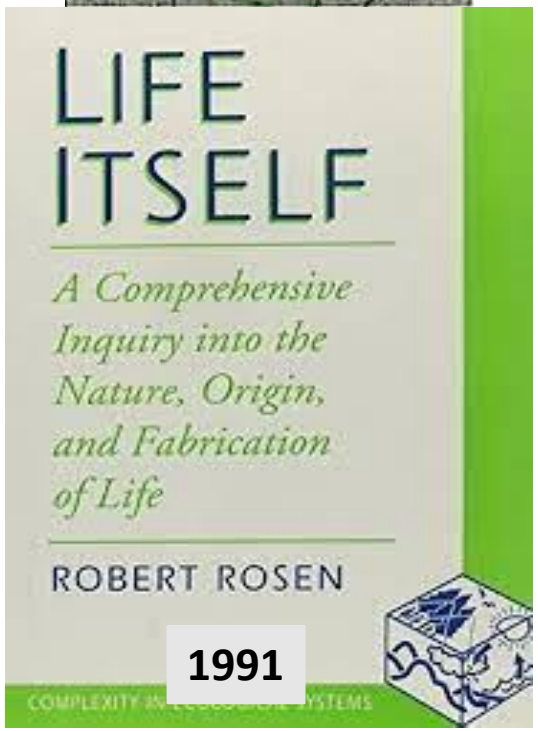
Defined across the epistemic cut!



1985

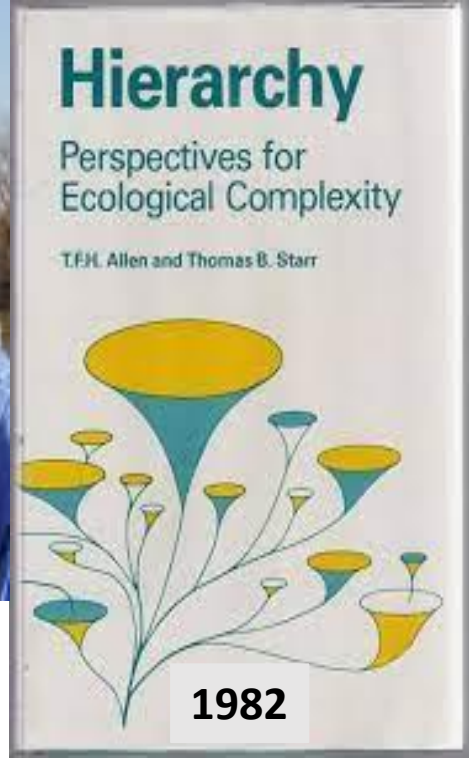


Stanley N. Salthe

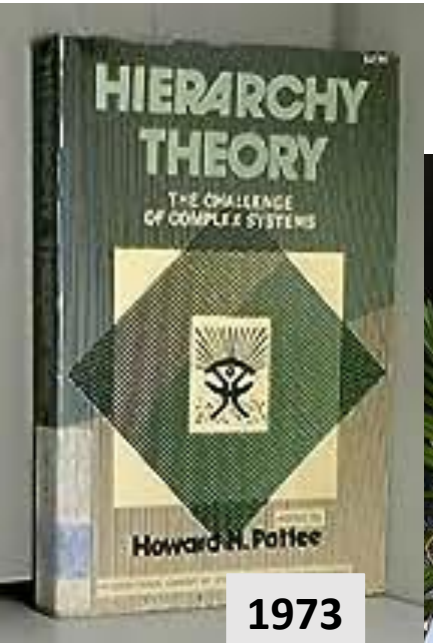


1991

Timothy F.H. Allen

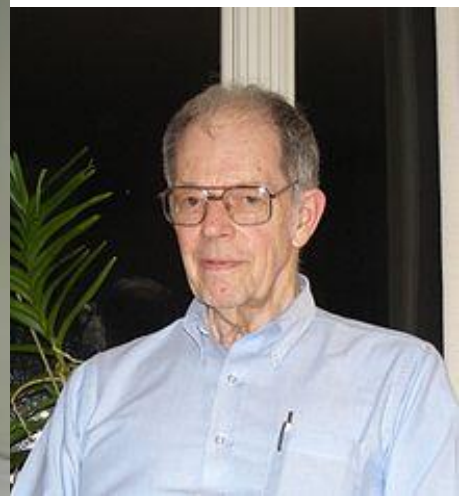


1982

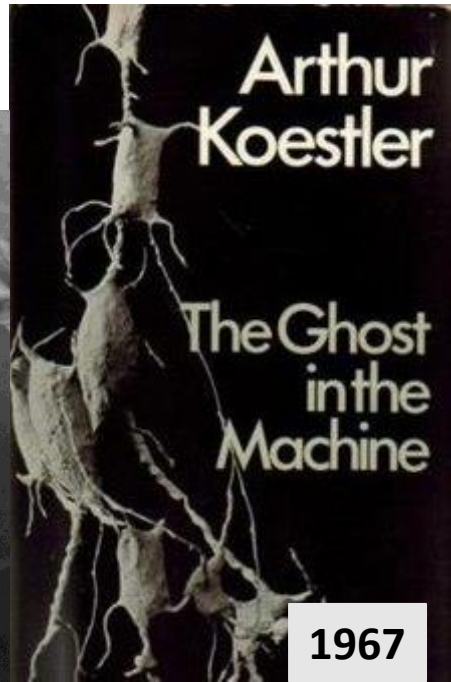


1973

Howard H. Pattee



THE HOLON &
HOLARCHIES



1967

SUDOKU EFFECT!

MUTUAL INFORMATION

The ecological network niche

= the UMWELT of a salmon

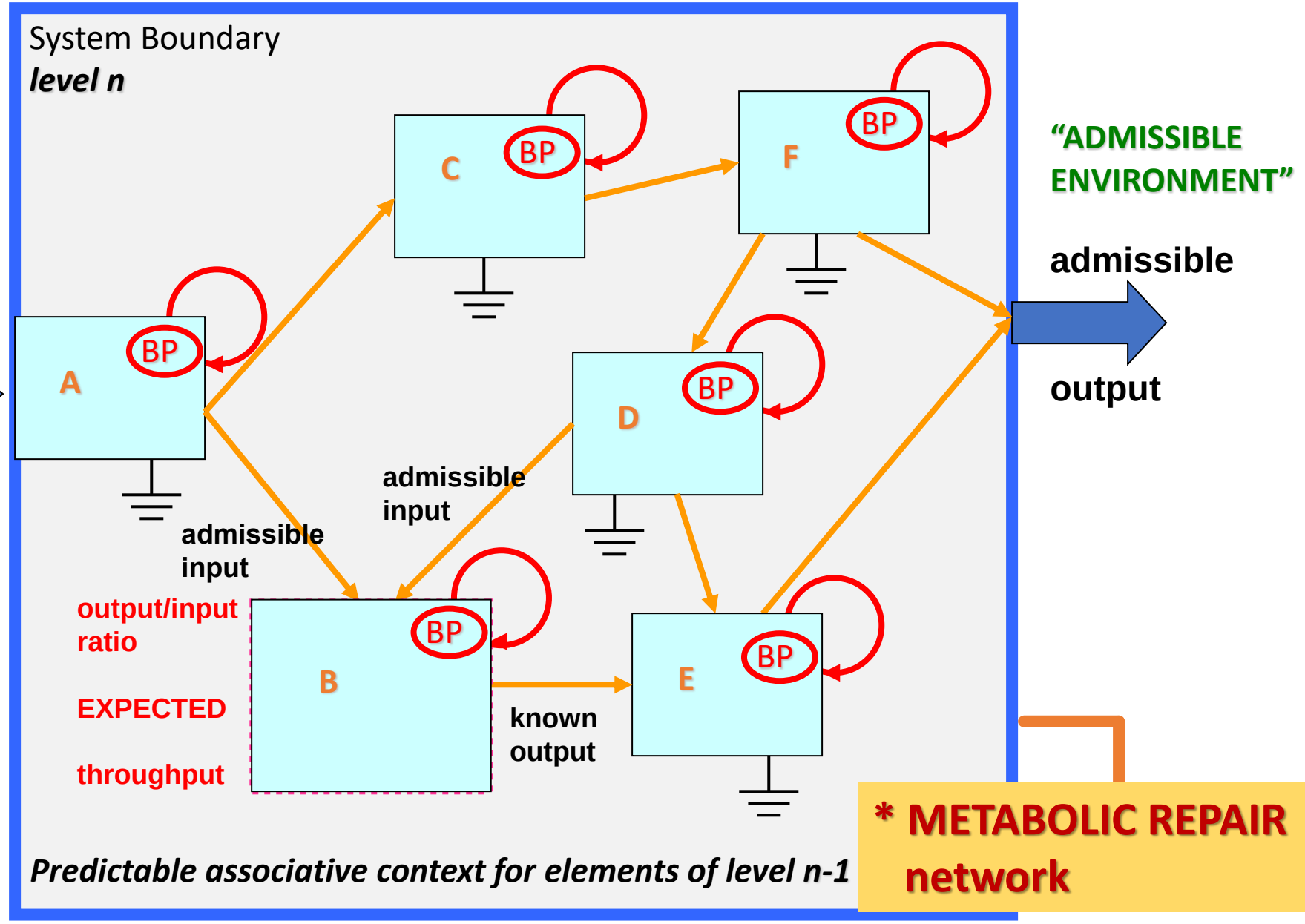
DIRECT INFORMATION

The genetic information

= how to produce an instance of salmon

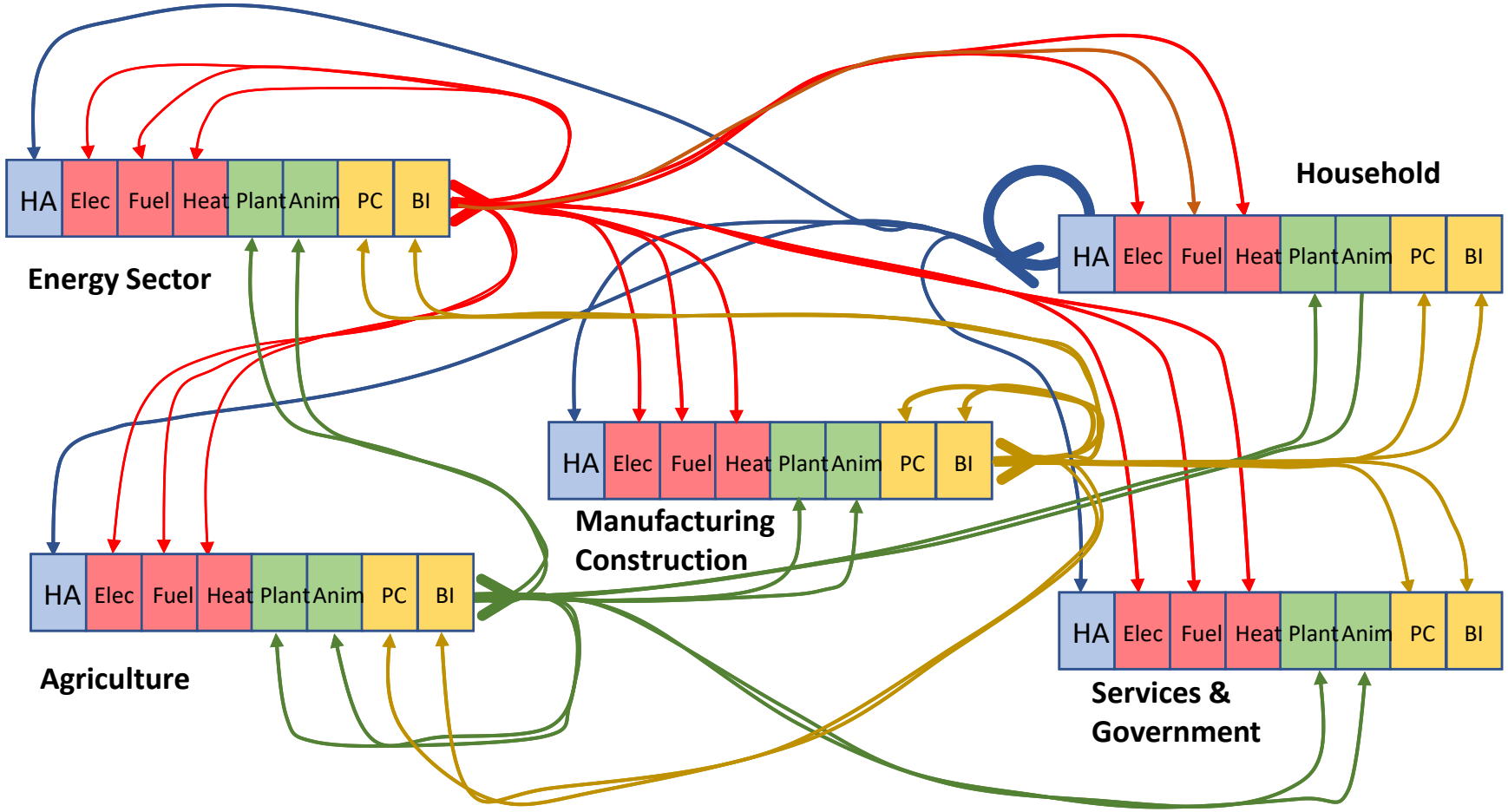
purpose driven agent with an umwelt-based identity

"ADMISSIBLE ENVIRONMENT"



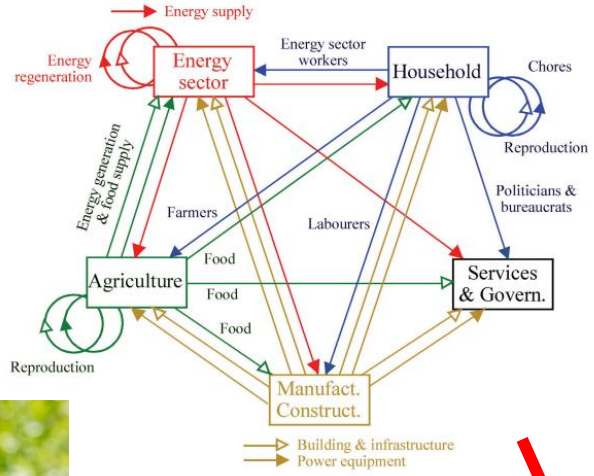
Definition of mutual information about the nodes in a MR-network*

The metabolic pattern of society: looking at the RELATIONS OVER vectors describing different end-uses in different functional compartments of society

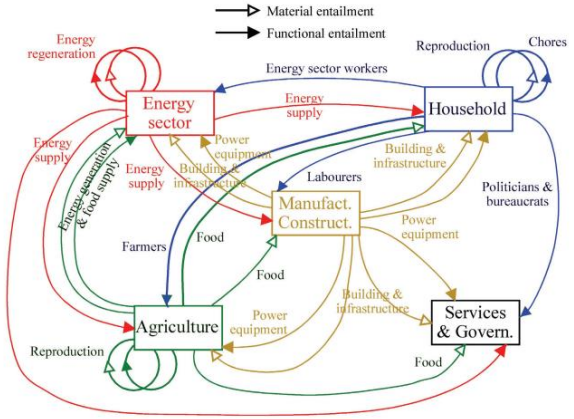


The economy reproduces the processes producing and consuming goods and services . . .

Nicholas Georgescu-Roegen



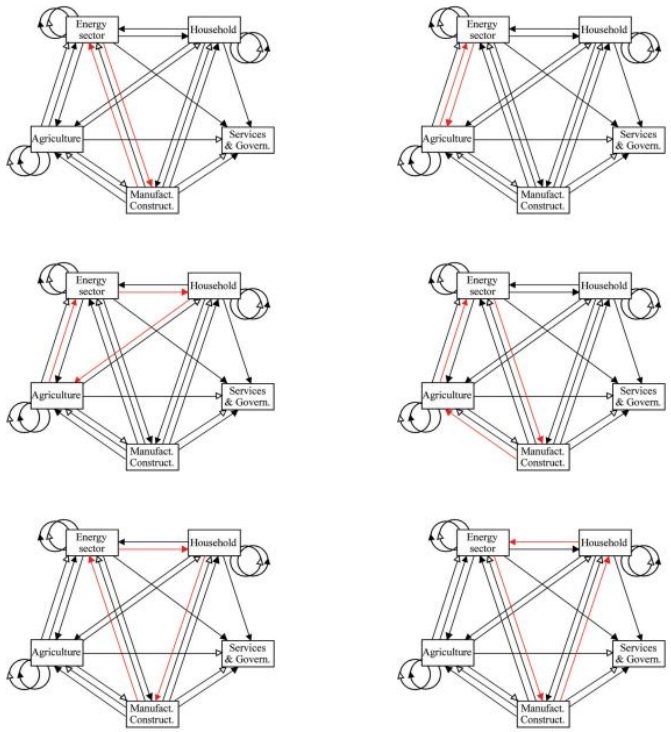
Transforming the graph into a pentagram . . .



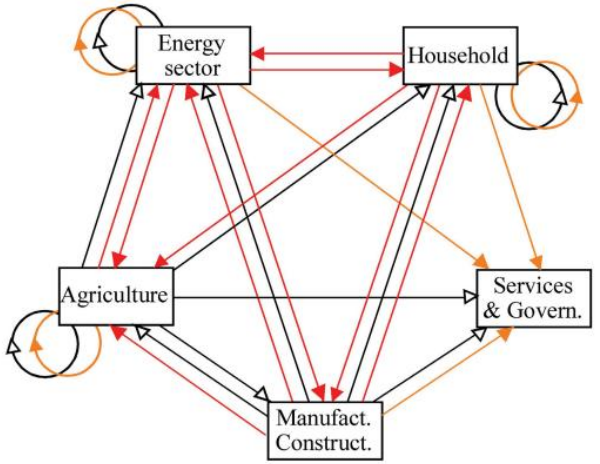
Metabolic Repair Network (MRN)

Aloisius Louie

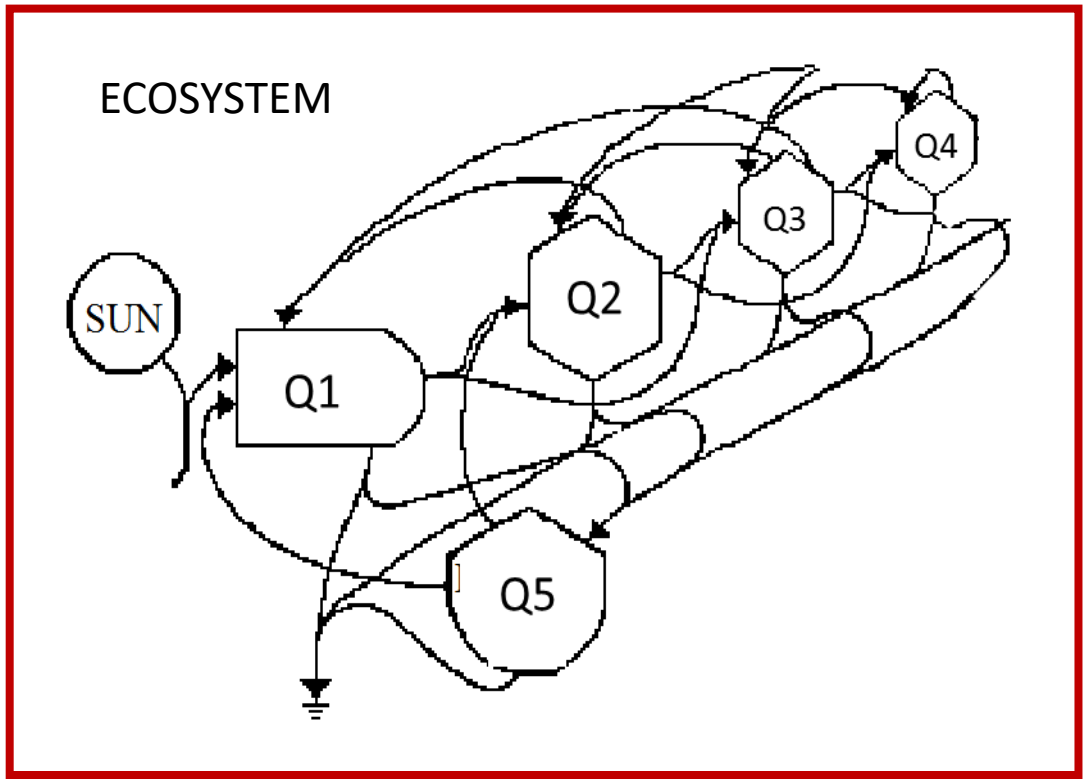
Using relational biology to conceptualize the analysis



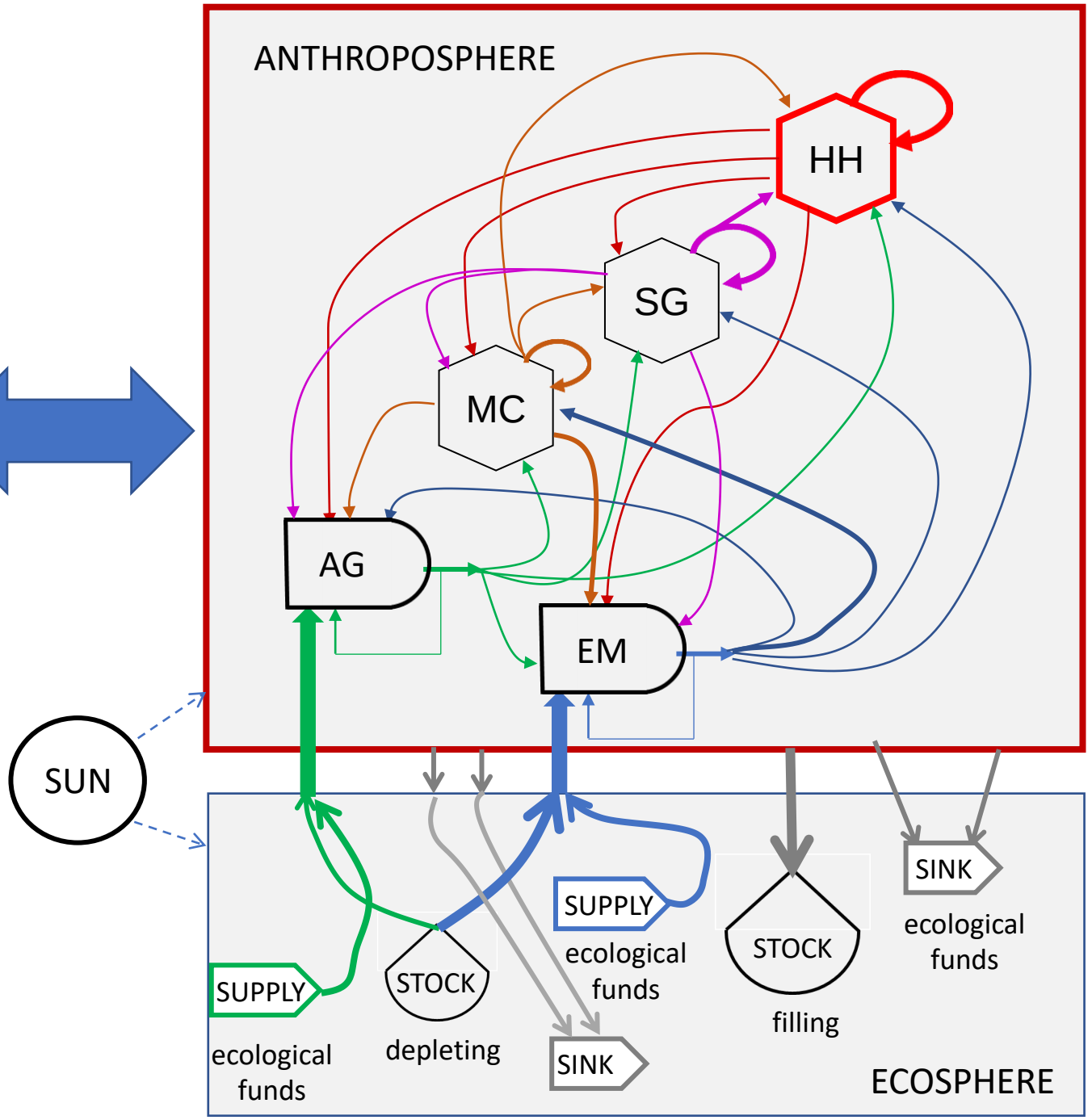
Identifying hierarchical cycles



Confirming that the MRN is **closed to efficient causation!**



Q1 → AG – Agriculture
Q1 → EM – Energy and Mining
Q2 → MC – Manufacturing and Construction
Q3 → SG – Service and Government
Q4 → HH – Household Sector (final consumption)
Q5 → ECOSPHERE



4. The adaptive cycle in theoretical ecology

The adaptive cycle (Holling)

In their semiotic process ecosystems send messages to themselves in the future (Margalef). in this way, at each cycle, they preserve and update, the integrated sets of identities operating in them. This requires adapting and integrating the impredicative relations over functional and structural elements by combining:

* METABOLIC codes – guaranteeing the structural coupling across levels;

* HOLONIC relations - guaranteeing meaningful functional coupling (parts/whole) across levels;

* GENETIC codes – guaranteeing the stability of the identity of *purpose driven agents with an UMWELT/identity* defined across different scales inside MR-Networks.

NOTIONAL

LOCAL SCALE

LARGE SCALE

NOTIONAL

TYPES

Ω release

GENOTYPE ←→ NICHE

direct ←→ mutual

represent*

exploitation r

IMMATURE ECOSYSTEMS

Weak mutual information

fast growth (short period)

represent**

TYPES

* direct information
(information carriers)

transduce

** mutual information
(sudoku effect)

apply

PHENOTYPE ←→ HABITAT

α reorganization

apply

slow adjustments (long period)

MATURE ECOSYSTEMS

Strong mutual information

conservation K

TOKENS

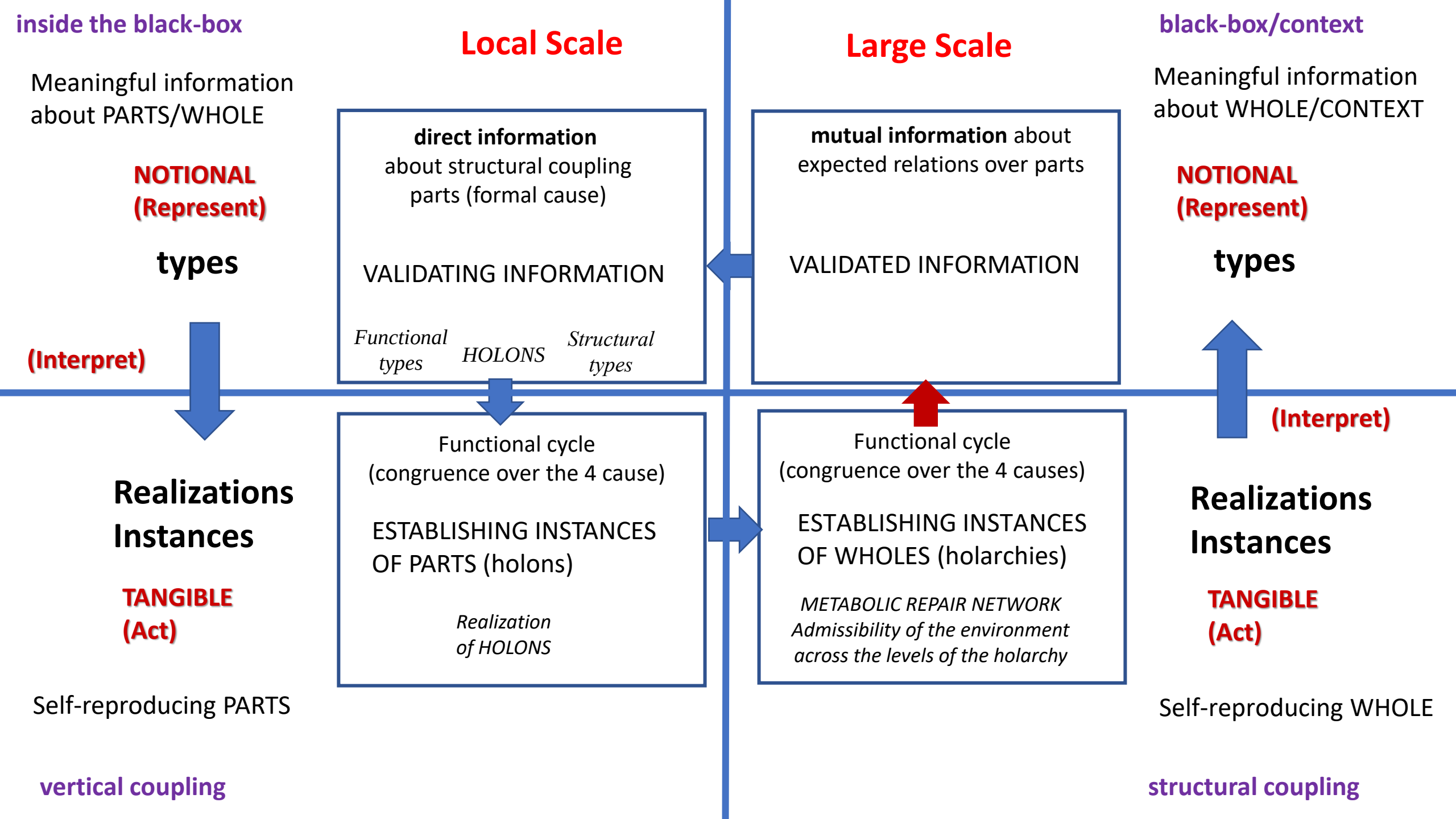
TOKENS

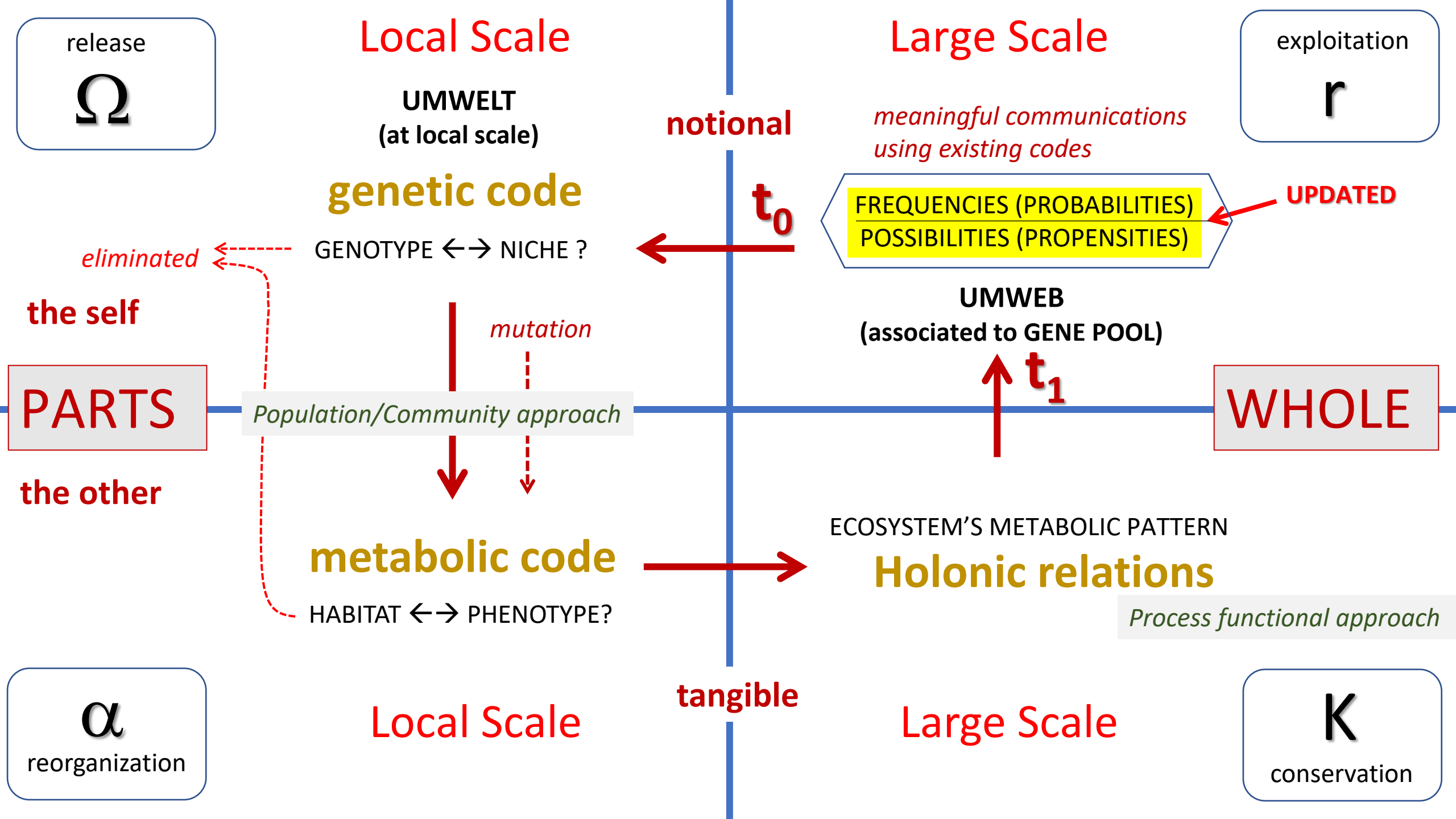
TANGIBLE

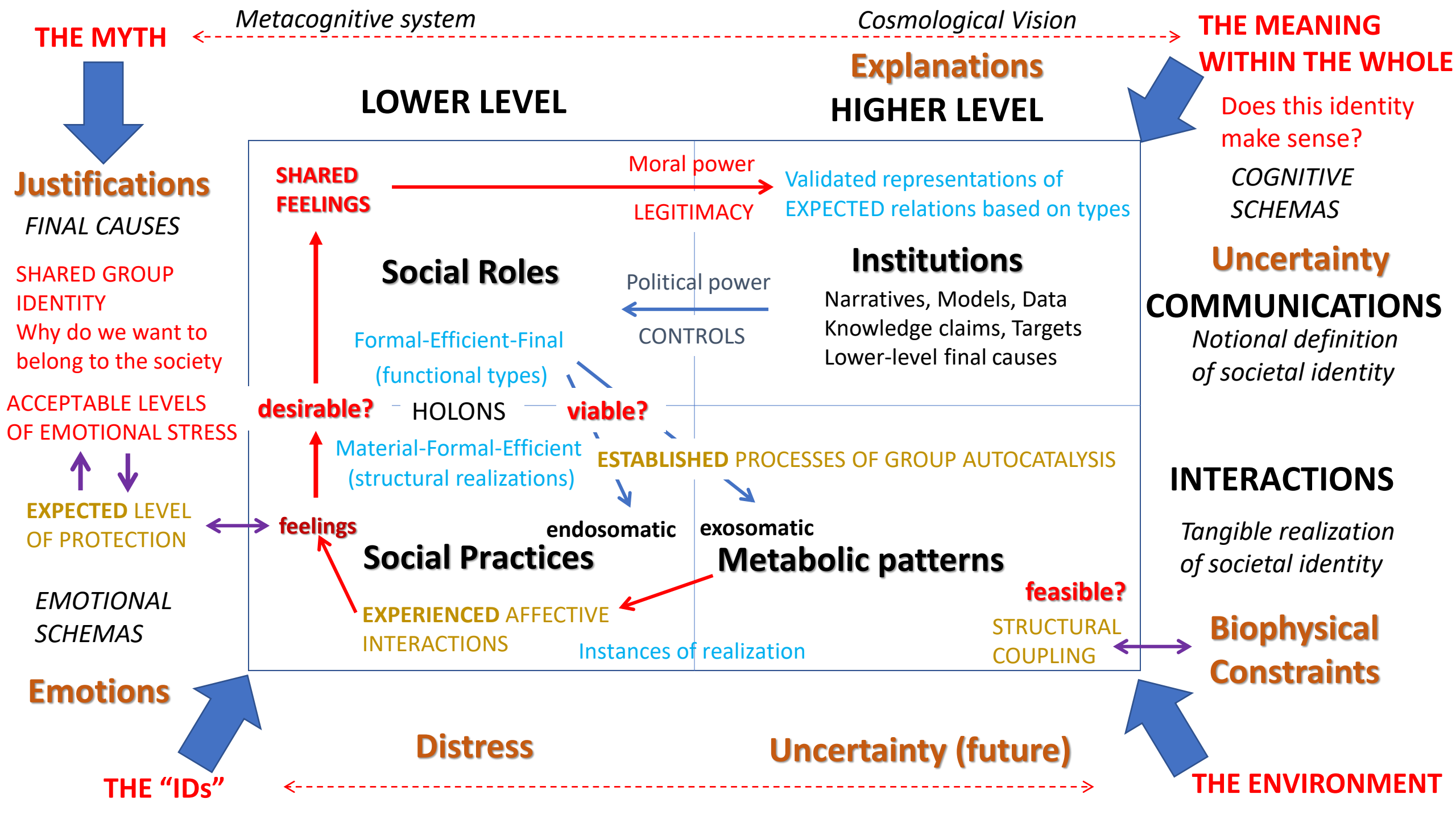
LOCAL SCALE

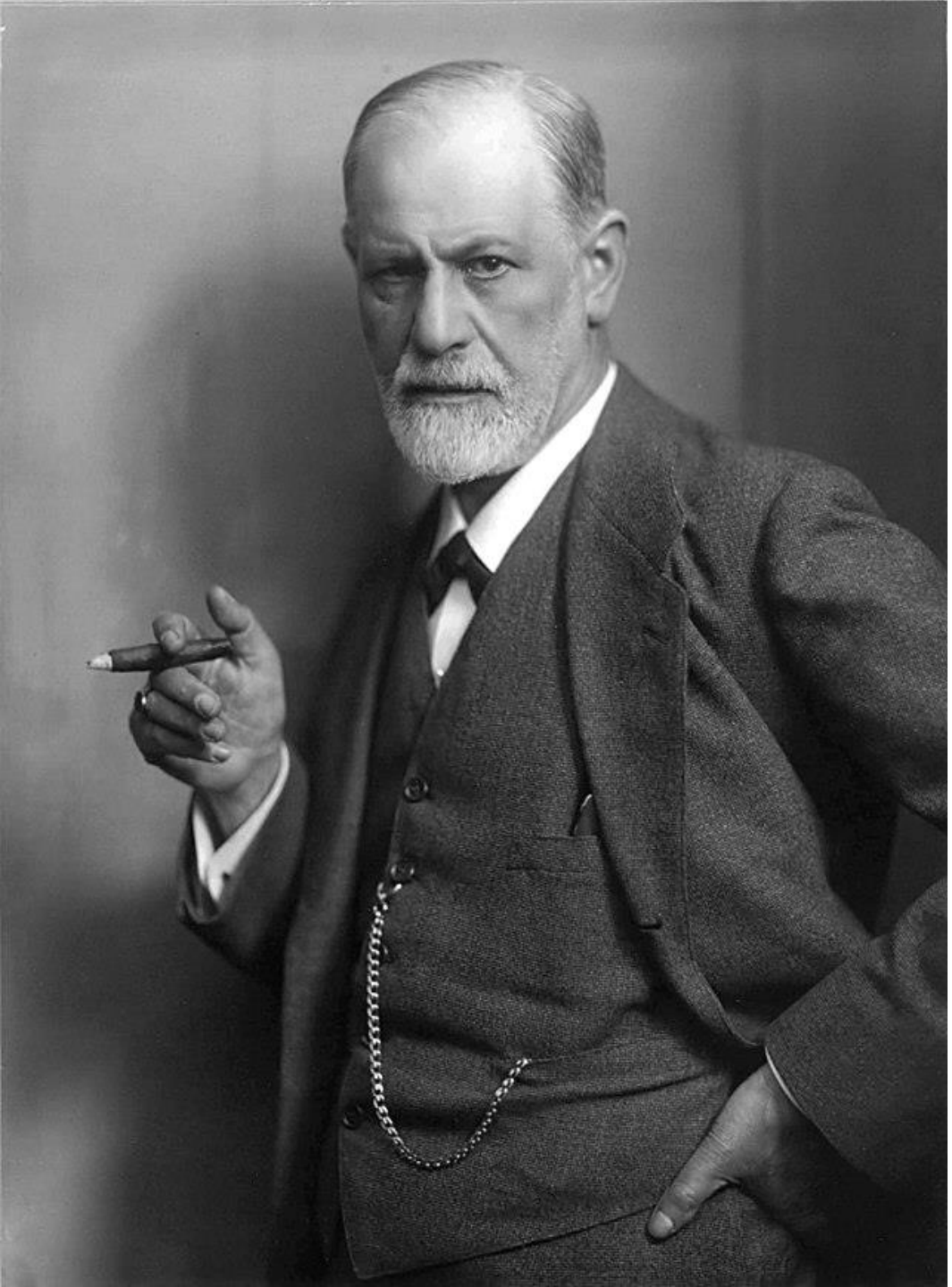
LARGE SCALE

TANGIBLE


inside the black-box
Local Scale
Large Scale
black-box/context
Meaningful information about PARTS/WHOLE
direct information about structural coupling parts (formal cause)
mutual information about expected relations over parts
Meaningful information about WHOLE/CONTEXT
NOTIONAL (Represent)
VALIDATING INFORMATION
VALIDATED INFORMATION
NOTIONAL (Represent)
types
Functional types
HOLONS
Structural types
types
(Interpret)
(Interpret)
Functional cycle (congruence over the 4 cause)
Functional cycle (congruence over the 4 causes)
Realizations Instances
ESTABLISHING INSTANCES OF PARTS (holons)
ESTABLISHING INSTANCES OF WHOLES (holarchies)
Realizations Instances
TANGIBLE (Act)
Realization of HOLONS
METABOLIC REPAIR NETWORK
Admissibility of the environment across the levels of the holarchy
TANGIBLE (Act)
Self-reproducing PARTS
Self-reproducing WHOLE
vertical coupling
structural coupling


release
Ω
Local Scale
UMWELT
(at local scale)
genetic code
GENOTYPE ←→ NICHE ?
eliminated
the self
mutation
PARTS
Population/Community approach
the other
HABITAT ←→ PHENOTYPE?
metabolic code
notional
t0
Large Scale
exploitation
r
meaningful communications
using existing codes
FREQUENCIES (PROBABILITIES)
POSSIBILITIES (PROPENSITIES)
UPDATED
UMWEB
(associated to GENE POOL)
t1
WHOLE
ECOSYSTEM'S METABOLIC PATTERN
Holonic relations
Process functional approach
tangible
α
reorganization
Local Scale
Large Scale
K
conservation


THE MYTH
Metacognitive system
Cosmological Vision
THE MEANING WITHIN THE WHOLE
Explanations
LOWER LEVEL
HIGHER LEVEL
Does this identity make sense?
COGNITIVE SCHEMAS
Justifications
FINAL CAUSES
SHARED GROUP IDENTITY
Why do we want to belong to the society
SHARED FEELINGS
Moral power
LEGITIMACY
Validated representations of EXPECTED relations based on types
Social Roles
Political power
CONTROLS
Institutions
Narratives, Models, Data
Knowledge claims, Targets
Lower-level final causes
Uncertainty
COMMUNICATIONS
Notional definition of societal identity
Formal-Efficient-Final
(functional types)
ACCEPTABLE LEVELS OF EMOTIONAL STRESS
desirable?
HOLONS
viable?
Material-Formal-Efficient
(structural realizations)
ESTABLISHED PROCESSES OF GROUP AUTOCATALYSIS
INTERACTIONS
EXPECTED LEVEL OF PROTECTION
feelings
endosomatic
exosomatic
Social Practices
Metabolic patterns
Tangible realization of societal identity
EMOTIONAL SCHEMAS
feasible?
EXPERIENCED AFFECTIVE INTERACTIONS
STRUCTURAL COUPLING
Biophysical Constraints
Instances of realization
Emotions
Distress
Uncertainty (future)
THE "IDs"
THE ENVIRONMENT

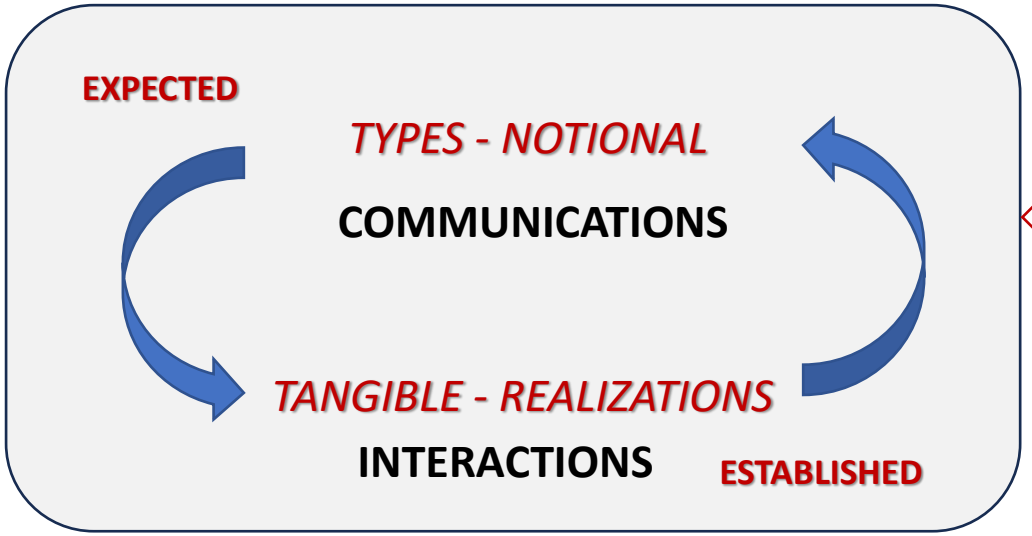


CONCLUSION

The biosemiotic process in ecological systems

stable metabolic pattern = meaningful information

GAIA, the experience done in the TAO, gives meaning to the process and its components



BIOPHYSICALLY FEASIBLE and VIABLE

⟺ **EXPERIENCED**

ECOLOGICAL PROCESSES

preservation and adaptation of species and ecosystem identities

The biosemiotic process in social-ecological systems

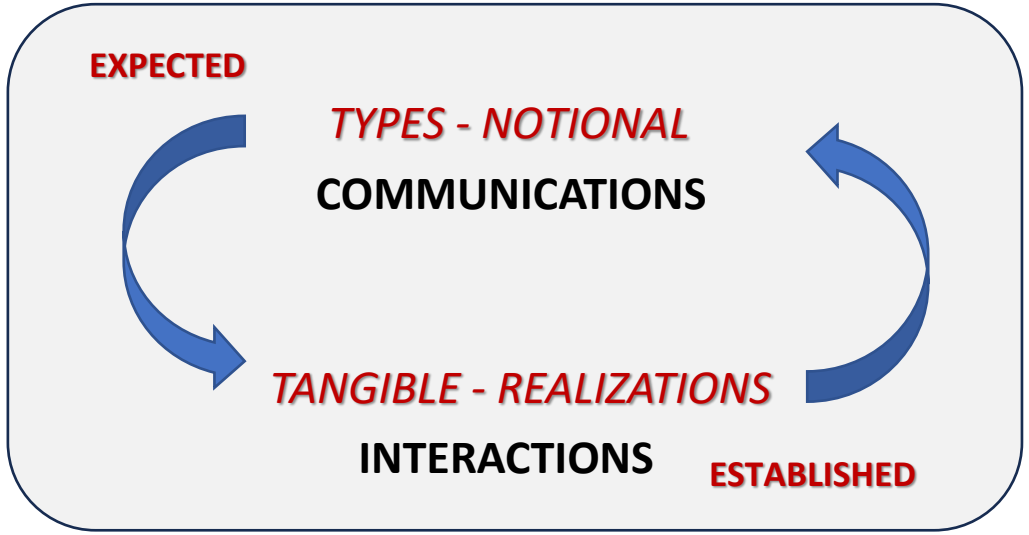
feelings of belonging = desirable identity = stable identity

The ability to generate a bundle of "feelings of belonging" to a chosen identity, giving meaning to communications taking place inside the process

SELF-REFERENTIALITY: they use a language to communicate to themselves:

(i) "who they are"; and

(ii) "why they do what they do"



PSYCHIC STRUCTURE

"IT IS WORTH IT"

⟺ **EXPERIENCED**

SOCIAL PRACTICES

preservation and adaptation of a shared social identity

Validated knowledge based on narratives/taxonomies referring to types

Policy legends!

Delirium

Shared purpose giving justification to the chosen identity

Sociotechnical imaginaries

knowledge claims

rules/

data/mo

RAL POWER

INTERPRETAT

RPRETATION

e interactions

POLITICAL POWE

GUIDING ACTION

MONITORING AND CON

Loss of purpose

GROUP IDENTITY

the self

the other

Ecological Collapse!

EMBEDDING ECOSYSTEMS

outside

Metabolic pattern of biophysical interactions

Social Practices

inside

ture made of instances of humans feeling the effect of affective interactions

If you can read this slide, then you are still alive!

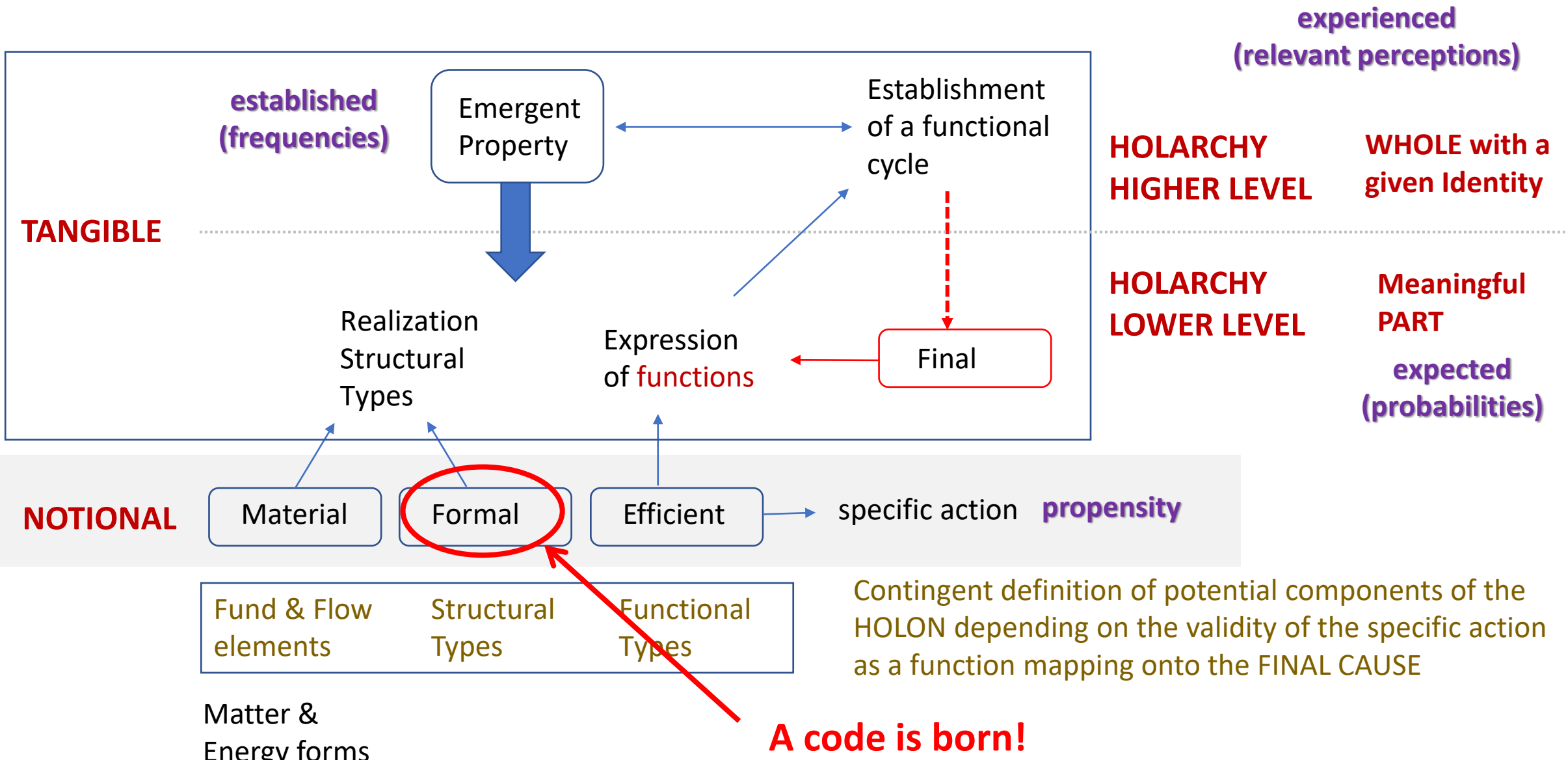
CONGRATULATIONS!

Thanks for your heroic attention

<Mario.Giampietro1@gmail.com>

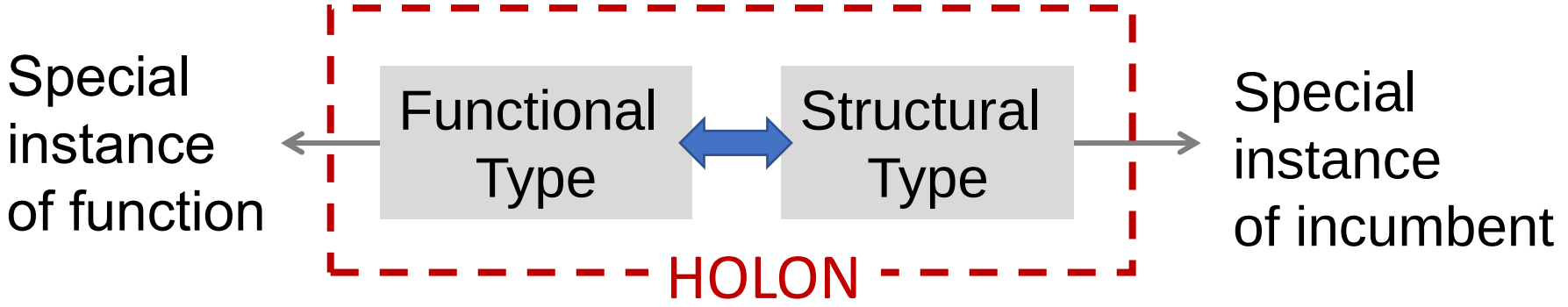
ADDITIONAL MATERIAL
FOR FURTHER DISCUSSIONS

The process of validation of the identity of the lower-level holon as a useful component of the functional cycle can be defined by using the 4 Aristotelian causes introduced in relational biology.



A holon is a unit of meaning that we use to identify a relevant agent recognized as a pertinent combination of a functional and a structural type.

However, when we are observing the external world we are observing **entities** that we perceive as being **special instances** of holons – ***a realization of a given combination of functional and structural types***!



US Presidency in 1817
vs
US Presidency in 2017

U.S. President

Trump
vs
Biden

MANY-TO-ONE and ONE-TO-MANY mappings when dealing with HOLONS

Functional types NOTIONAL	Instances TANGIBLE	Structural types NOTIONAL
US PRESIDENT	Obama Bush Trump Clinton	US BORN CITIZEN
US President Father of two Lawyer Basket player	Obama	Context of its liver US born citizen Passenger in a car Household member

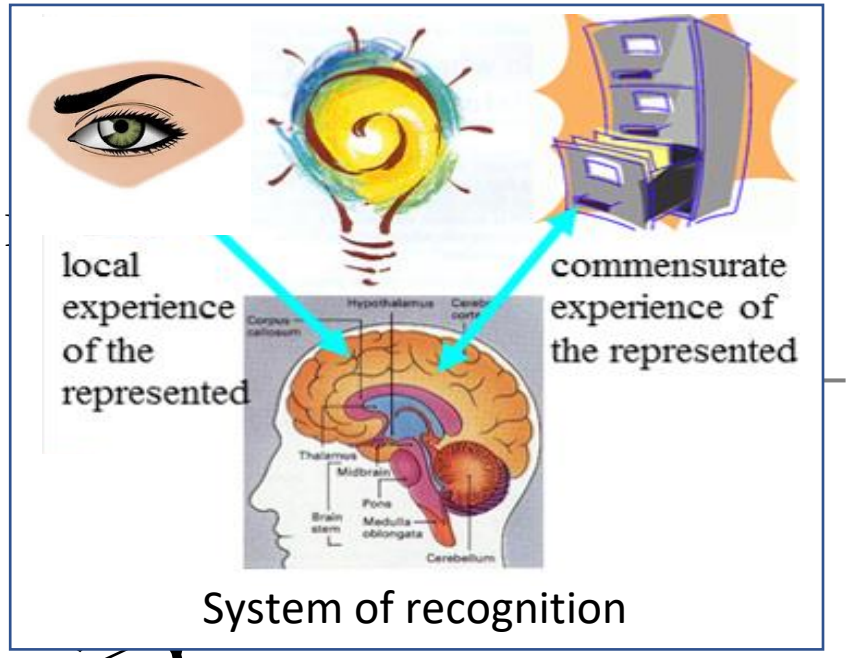
SYNCHRONIC

A spectre is haunting Reductionism . . .

	Structural	***Functional***
Type	Direct information	Mutual information
Instance	Structural coupling	Realization of whole/parts context/whole

DIACHRONIC

Functional types NOTIONAL	Instances TANGIBLE	Structural types NOTIONAL
Luxury Sedan	BMW 5-Series Audi A6 Cadillac CTS Lexus GS Volvo S90	Second hand vehicles Brand new vehicles

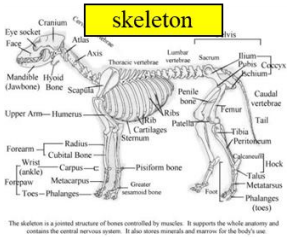


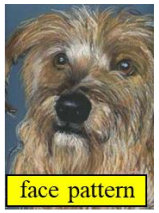
System of recognition

Expected

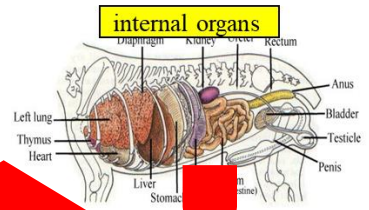
ONTOLOGY allowing a representation of the relations over attributes, types, categories

the 4 varieties of Belgian shepherd





face pattern



System of representations

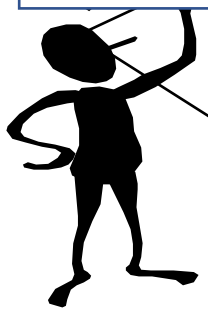
Notional

EPISTEMIC CUT

LOCAL SCALE

LARGE SCALE

Tangible

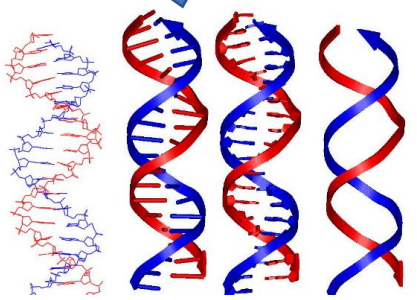


Experienced

Instance of organism belonging to the species *Canis Familiaris*

System of realizations

FABRICATION OF AN EQUIVALENCE CLASS OF REALIZATIONS OF TYPES



LARGER SCALE!

?

"Thor" (a dog) on the Golden Beach of Istanbul

Established

THE OTHER

"token" realization

EXTERNAL REFERENT

TANGIBLE

REALIZATIONS

CODE RECORD

"token" realization of an information carrier

MEMBER OF AN ONTOLOGY IN A GIVEN LANGUAGE

Representation of expected attributes

Type

Name

* Dog
* Chien
* Perro
* Cane
* 甘蔗 Gānzhè

Names of the code

shared information useful for action

* **ICONS**
* **INDEXES**
* **EMONS**

shared meaning of the name

NOTIONAL

FOR INTERACTION

FOR COMMUNICATION

Identify a relevant ontology:
* Identifying external referents to be used
* Using available knowledge claims before acting
* Checking the validity of knowledge claims

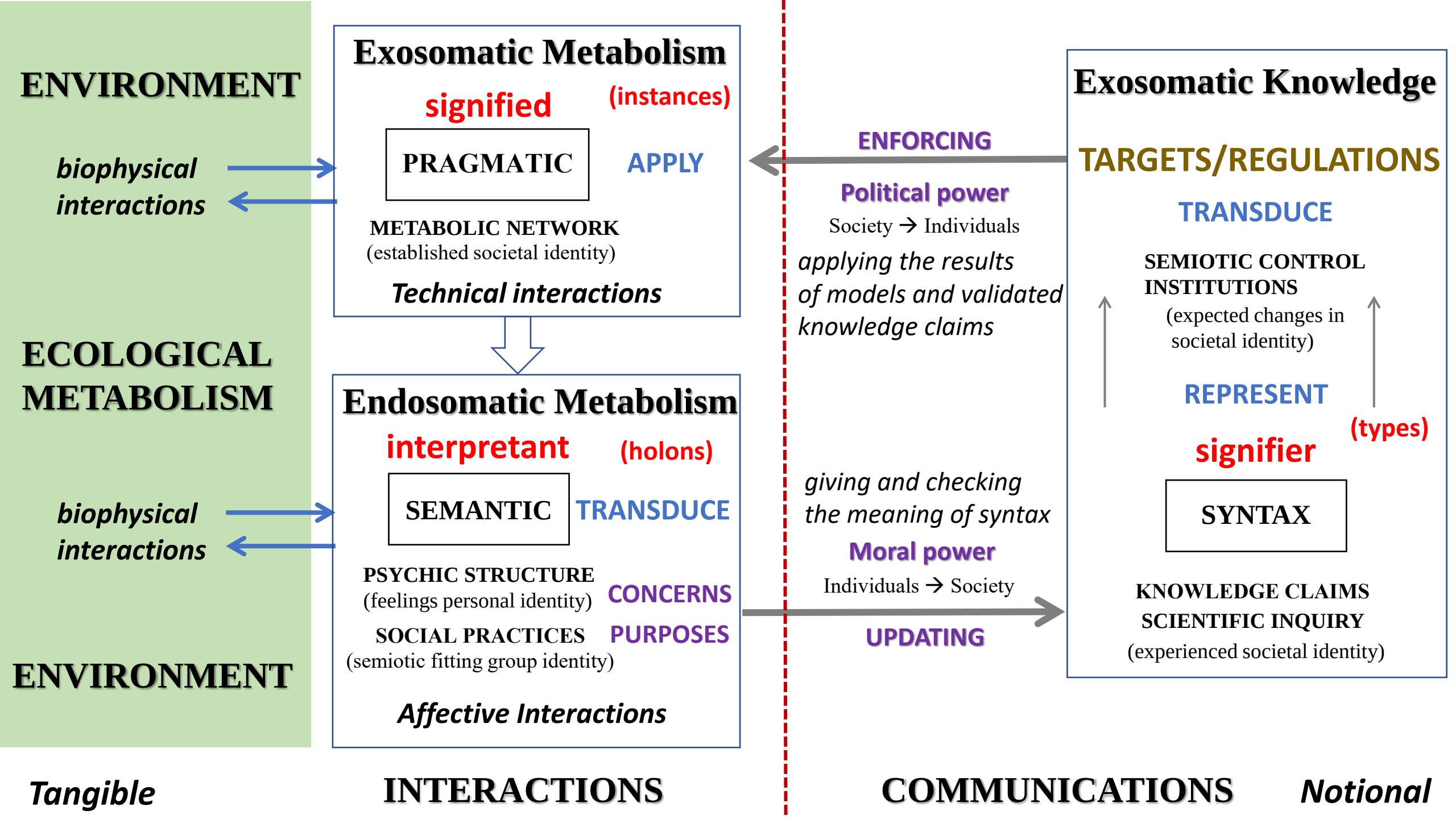
Share experiences:
* Updating the quality of the information
* Correcting and expanding knowledge claims
* Updating and expanding purposes and taboos

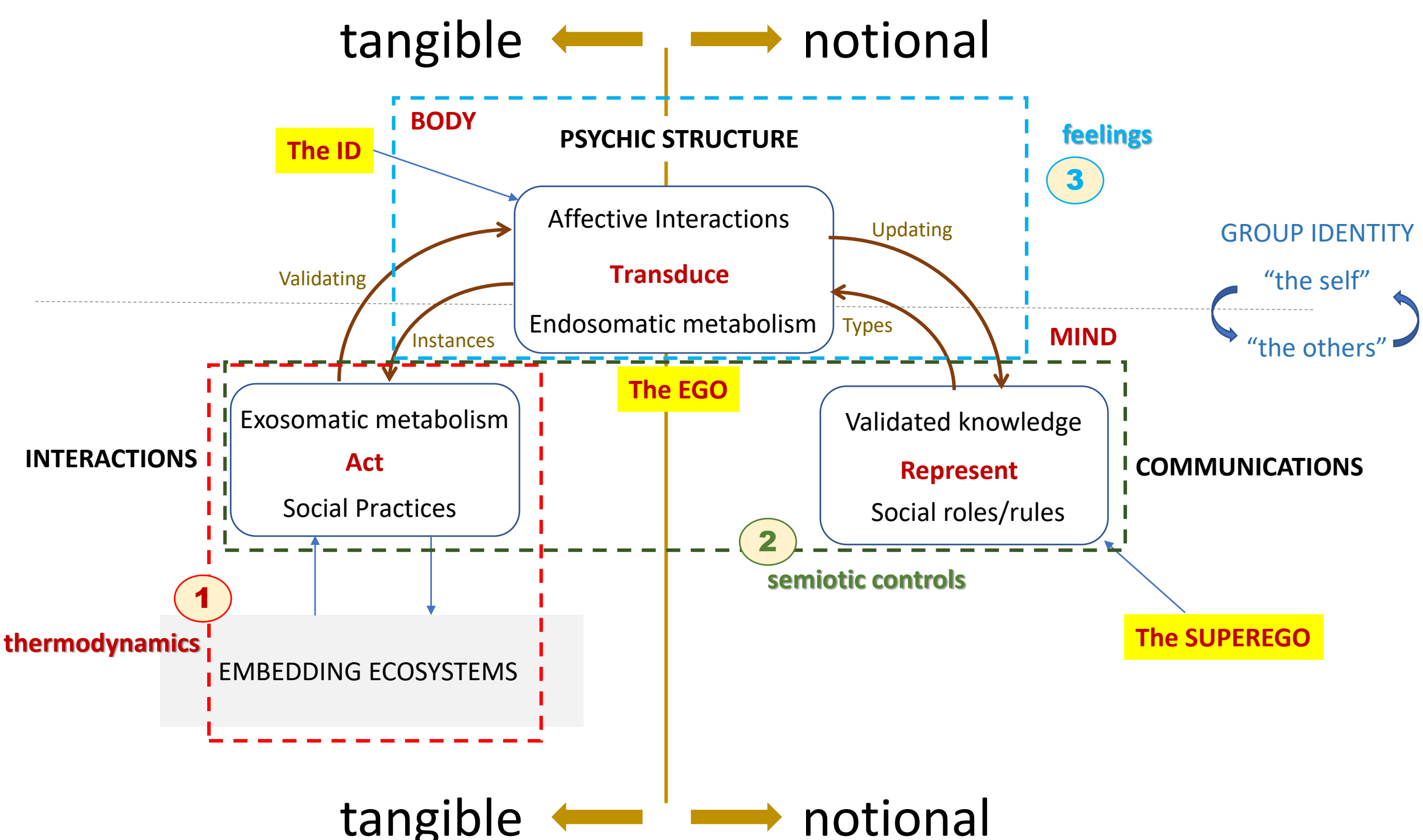
THE SELF

STABLE METABOLIC NETWORK?

LARGER SCALE TANGIBLE REALIZATION

STABLE IDENTITY OF THE SOCIAL SYSTEM?


ENVIRONMENT
biophysical interactions
ECOLOGICAL METABOLISM
biophysical interactions
ENVIRONMENT
Exosomatic Metabolism
signified
(instances)
PRAGMATIC
APPLY
METABOLIC NETWORK
(established societal identity)
Technical interactions
Endosomatic Metabolism
interpretant
(holons)
SEMANTIC
TRANSDUCE
PSYCHIC STRUCTURE
(feelings personal identity)
CONCERNS
SOCIAL PRACTICES
PURPOSES
(semiotic fitting group identity)
Affective Interactions
ENFORCING
Political power
Society → Individuals
applying the results of models and validated knowledge claims
giving and checking the meaning of syntax
Moral power
Individuals → Society
UPDATING
Exosomatic Knowledge
TARGETS/REGULATIONS
TRANSDUCE
SEMIOTIC CONTROL INSTITUTIONS
(expected changes in societal identity)
REPRESENT
(types)
signifier
SYNTAX
KNOWLEDGE CLAIMS
SCIENTIFIC INQUIRY
(experienced societal identity)
Tangible
INTERACTIONS
COMMUNICATIONS
Notional


tangible
notional
BODY
PSYCHIC STRUCTURE
The ID
feelings
3
Affective Interactions
Transduce
Endosomatic metabolism
Updating
Validating
Instances
Types
GROUP IDENTITY
"the self"
"the others"
MIND
The EGO
INTERACTIONS
Exosomatic metabolism
Act
Social Practices
Validated knowledge
Represent
Social roles/rules
COMMUNICATIONS
2
semiotic controls
1
thermodynamics
EMBEDDING ECOSYSTEMS
The SUPEREGO
tangible
notional