

Kyoto University Series Seminar on *What is Life?*

How does the self-identity maintain?

July 10 (Thu), 2007
16:30~18:00



Masatoshi Murase

**Yukawa Institute for
Theoretical Physics**

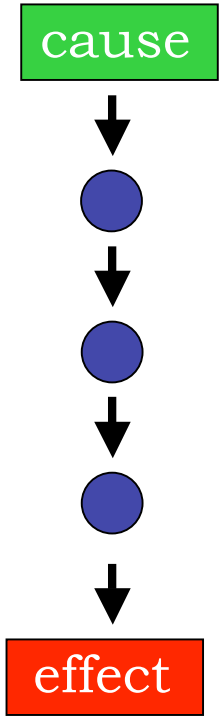


出所 : http://www.yukawa.kyoto-u.ac.jp/contents/about_us/yt100logo/index.htm

Traditional
Pathway Model

Phylogeny of recognition

Complex
Network Model



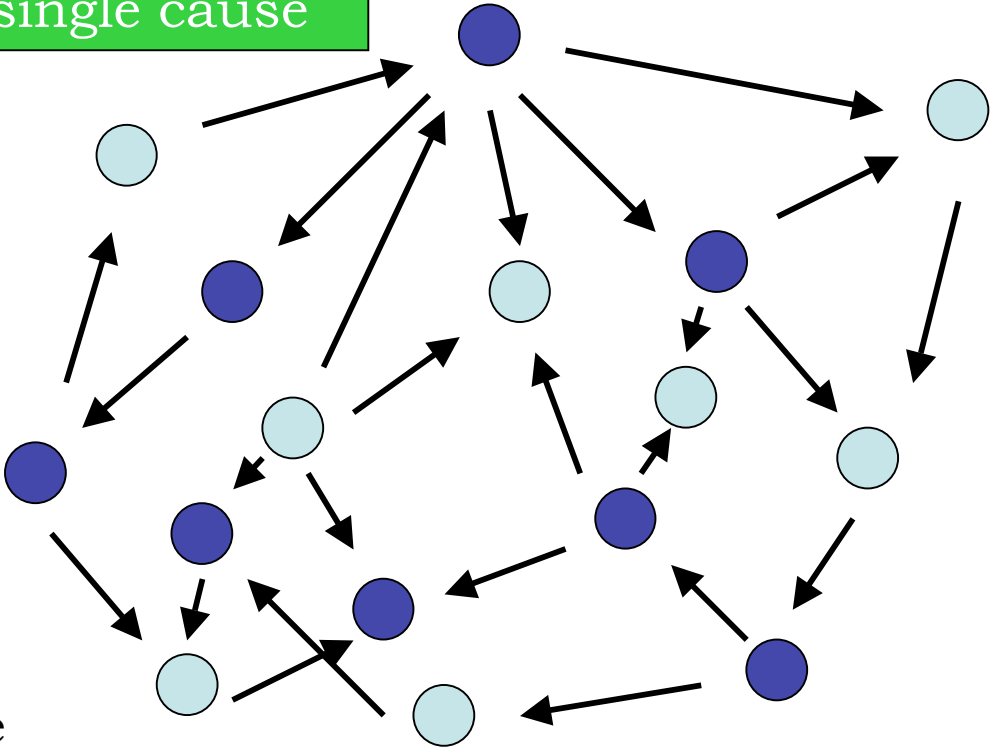
DNA

RNA

Protein

Phase Transition
Self-organization
Origin, Emergence

No single cause

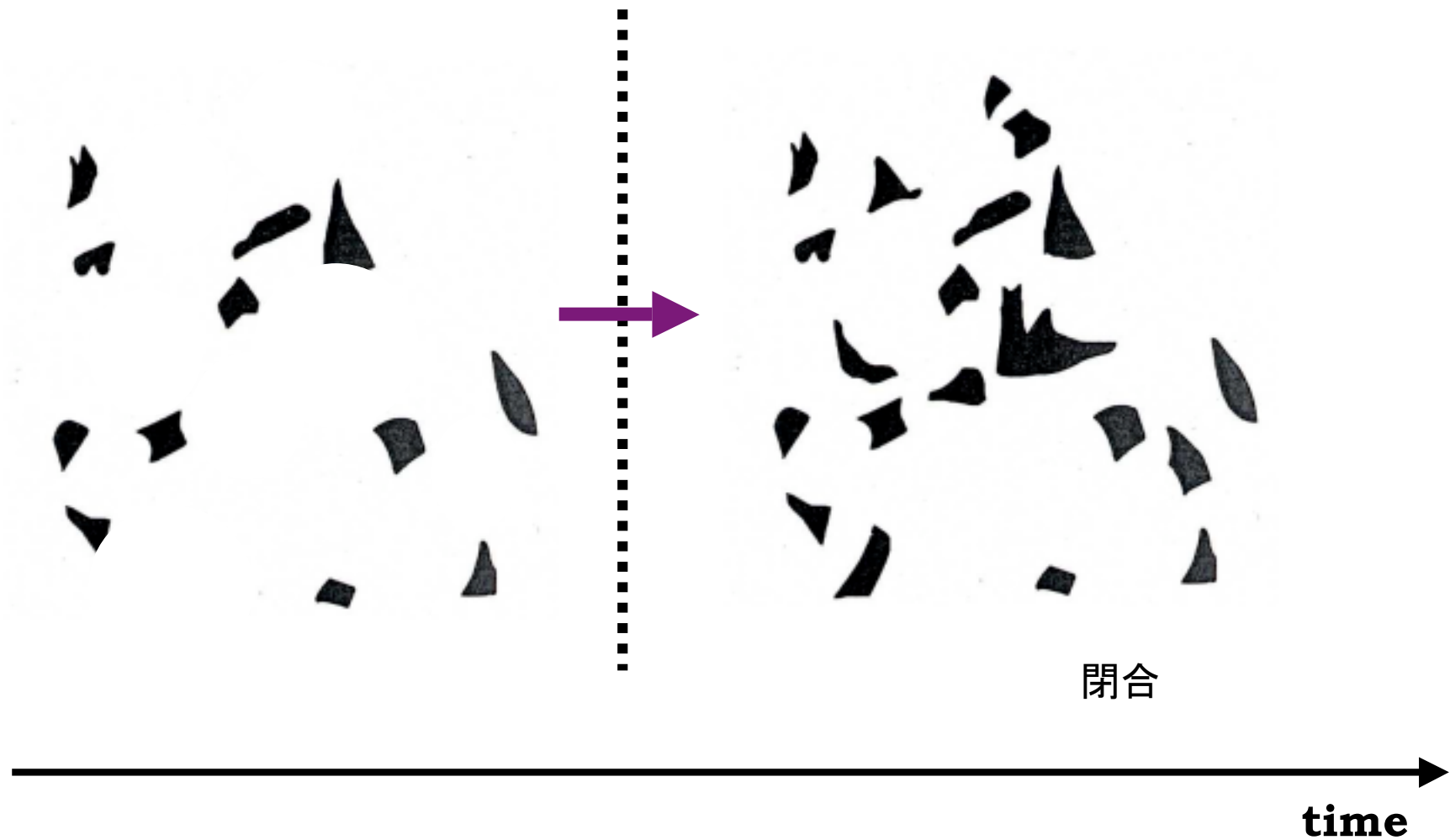


Effect as emergent property

Element with single function

Element with multiple functions

Development of recognition



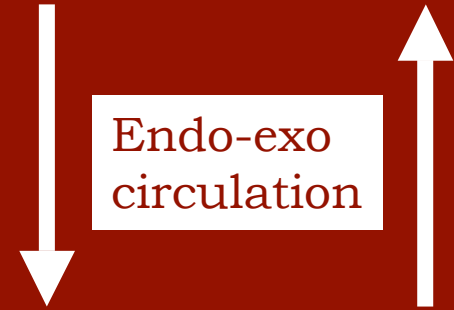
Exo-world



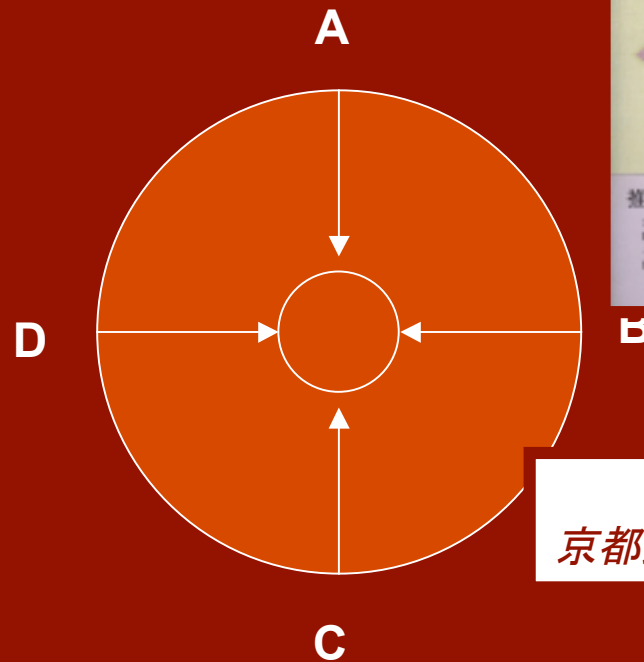
Western Thinking



Endo-exo
circulation



Eastern Thinking



村瀬 雅俊
京都大学学術出版会 (2000)

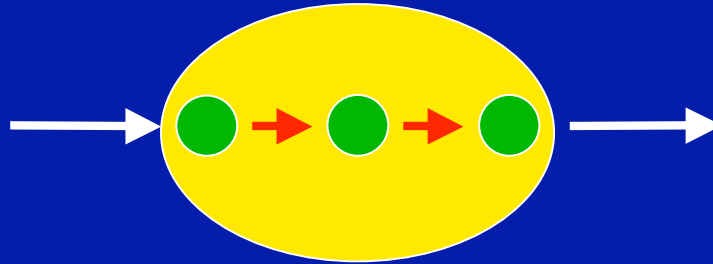
Endo-system

Unicellular organism

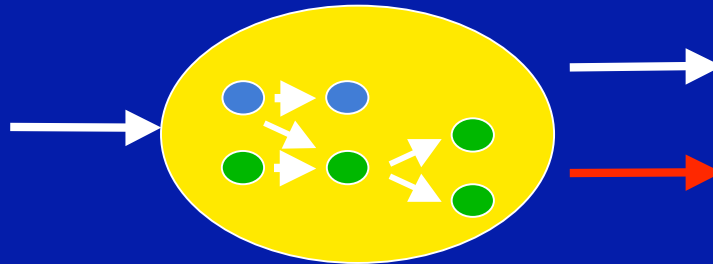
input

output

Reflection

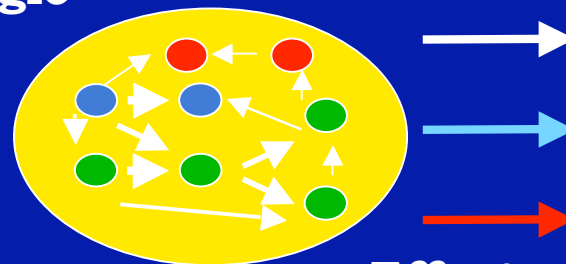


Semi-autonomy



Autonomy

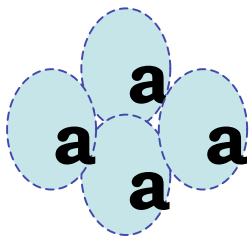
No single cause



Effect as Emergent phenomena

Two dimensions of evolution

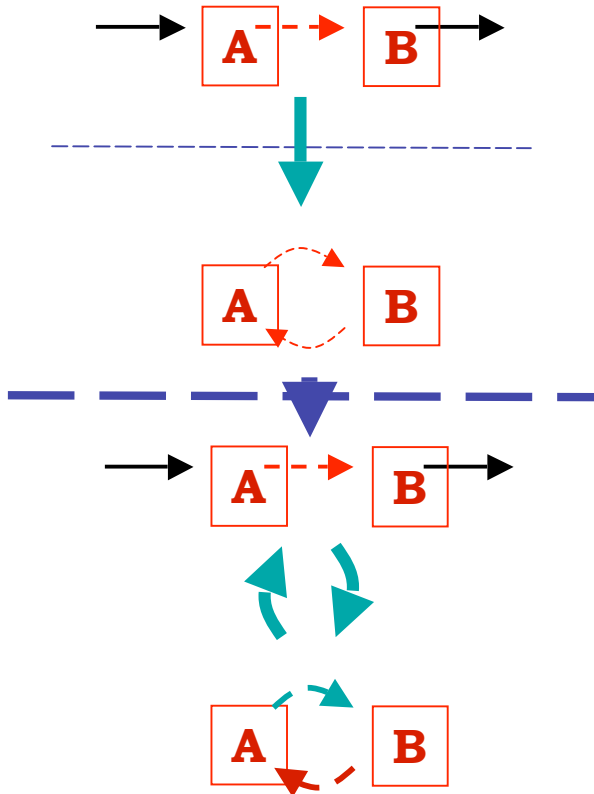
Self-replication



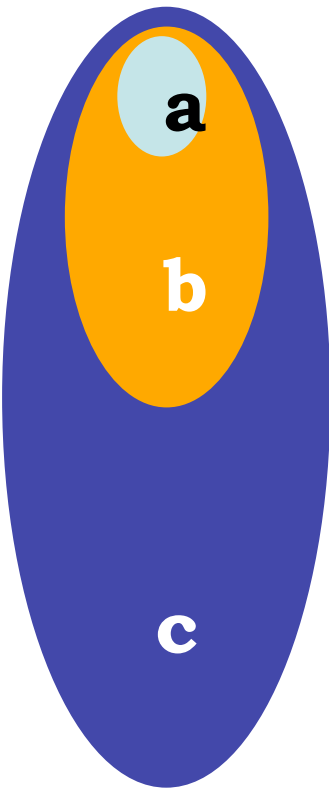
Fast process

Endo-exo circulation

From 'selection of unit' to 'selection of process'



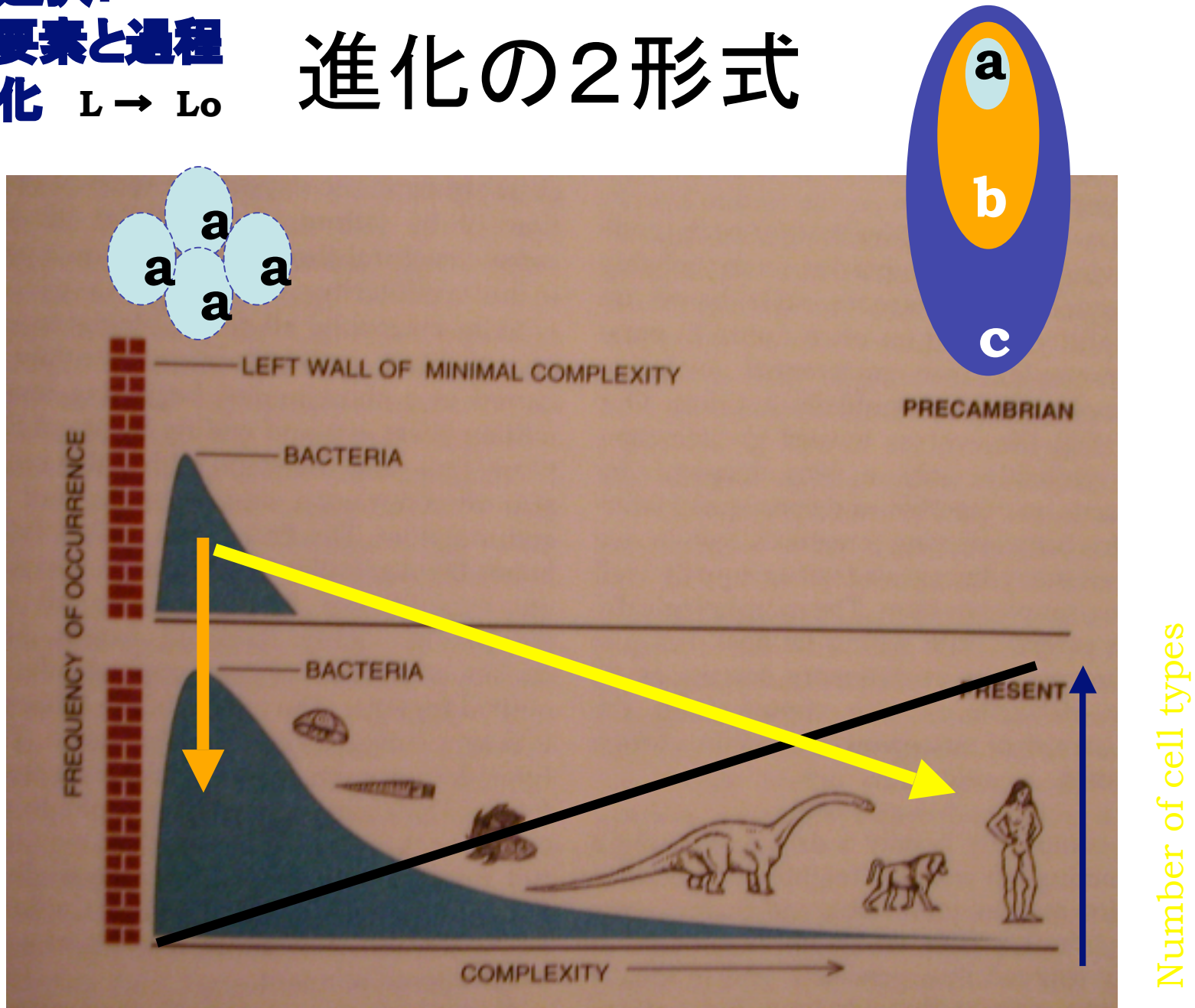
Internalization



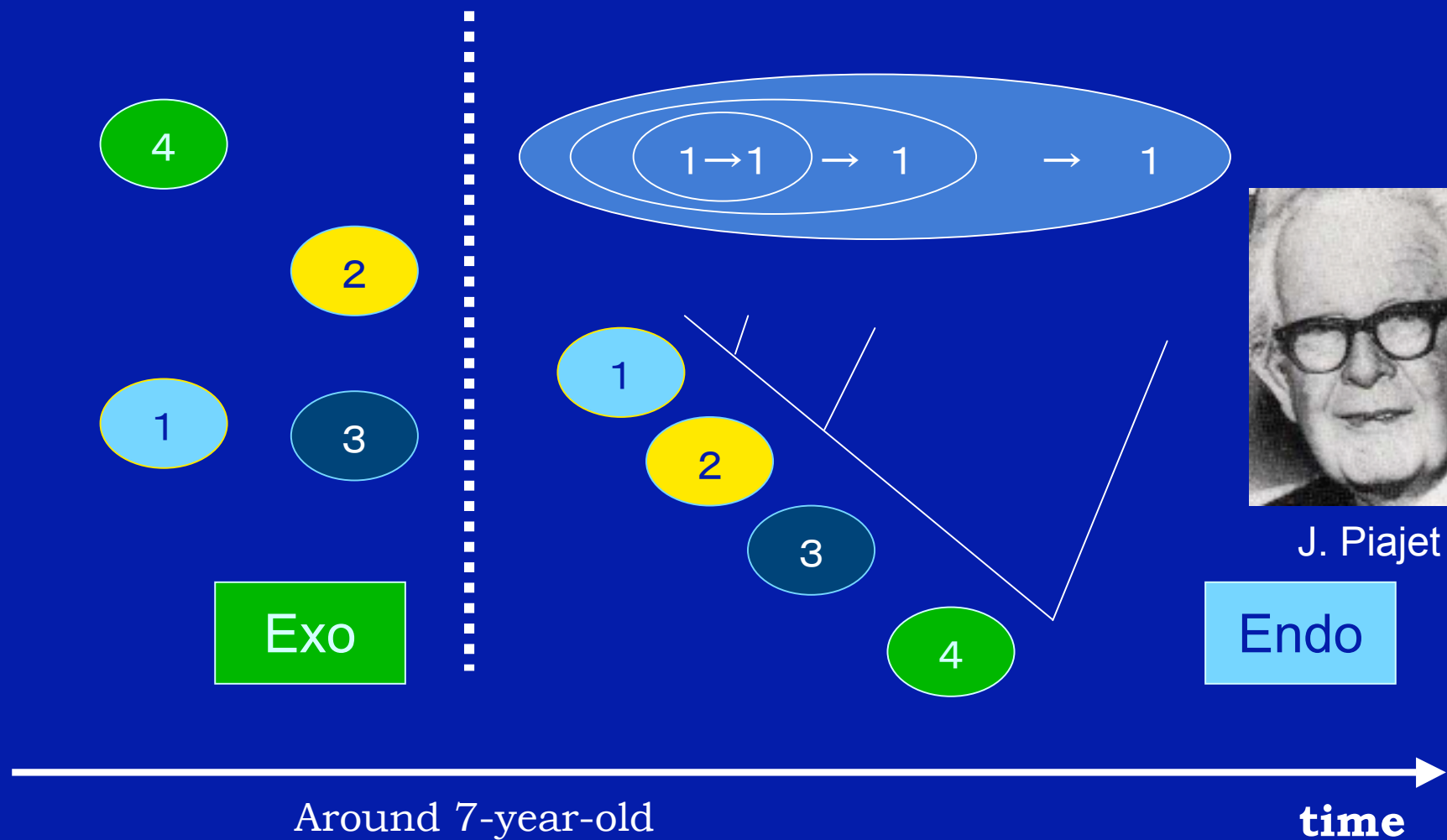
Slow process

進化的選択:
外的な要素と過程
の内在化 L → L₀

進化の2形式

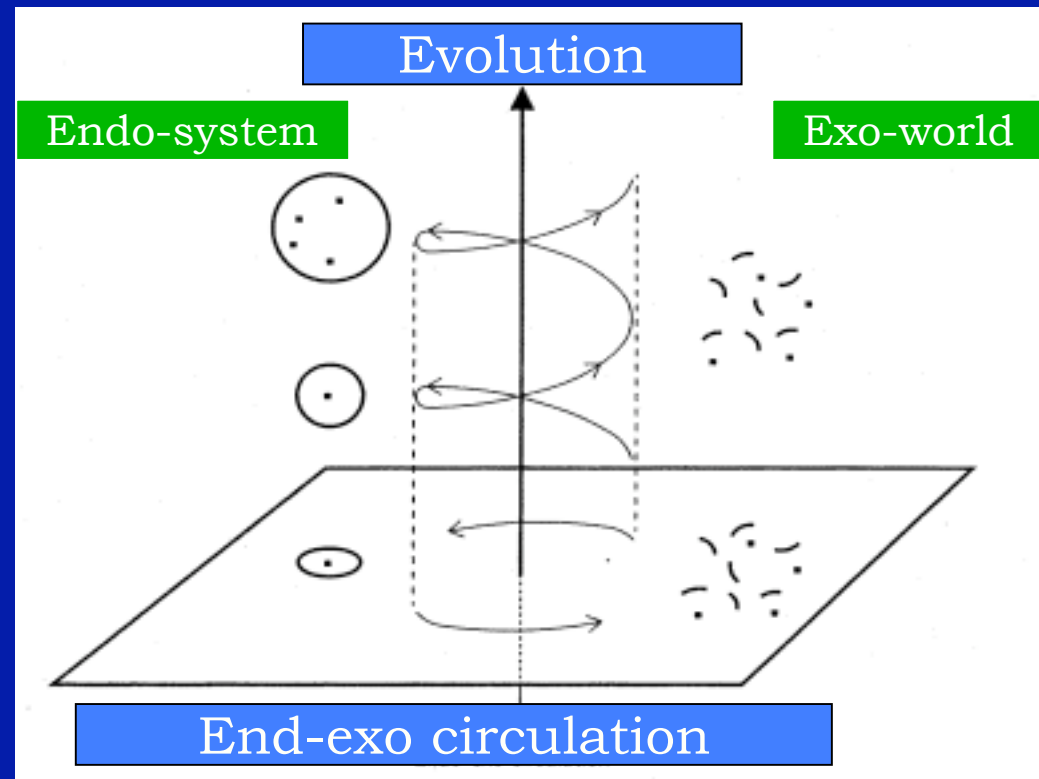
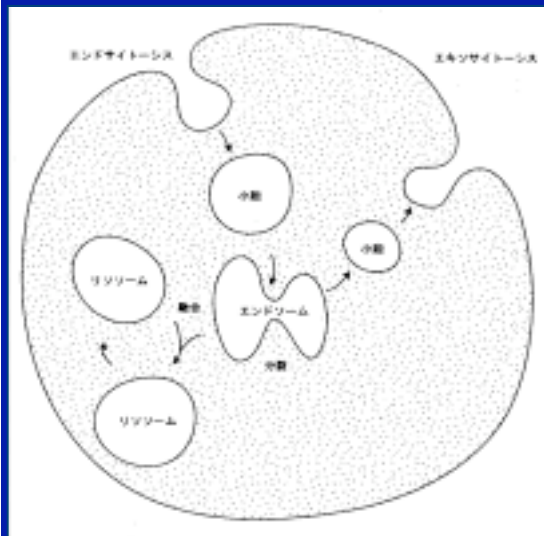
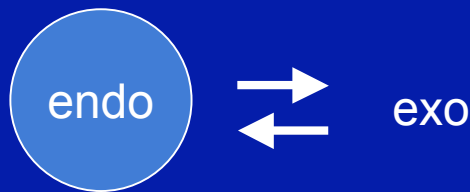


Concept of Number

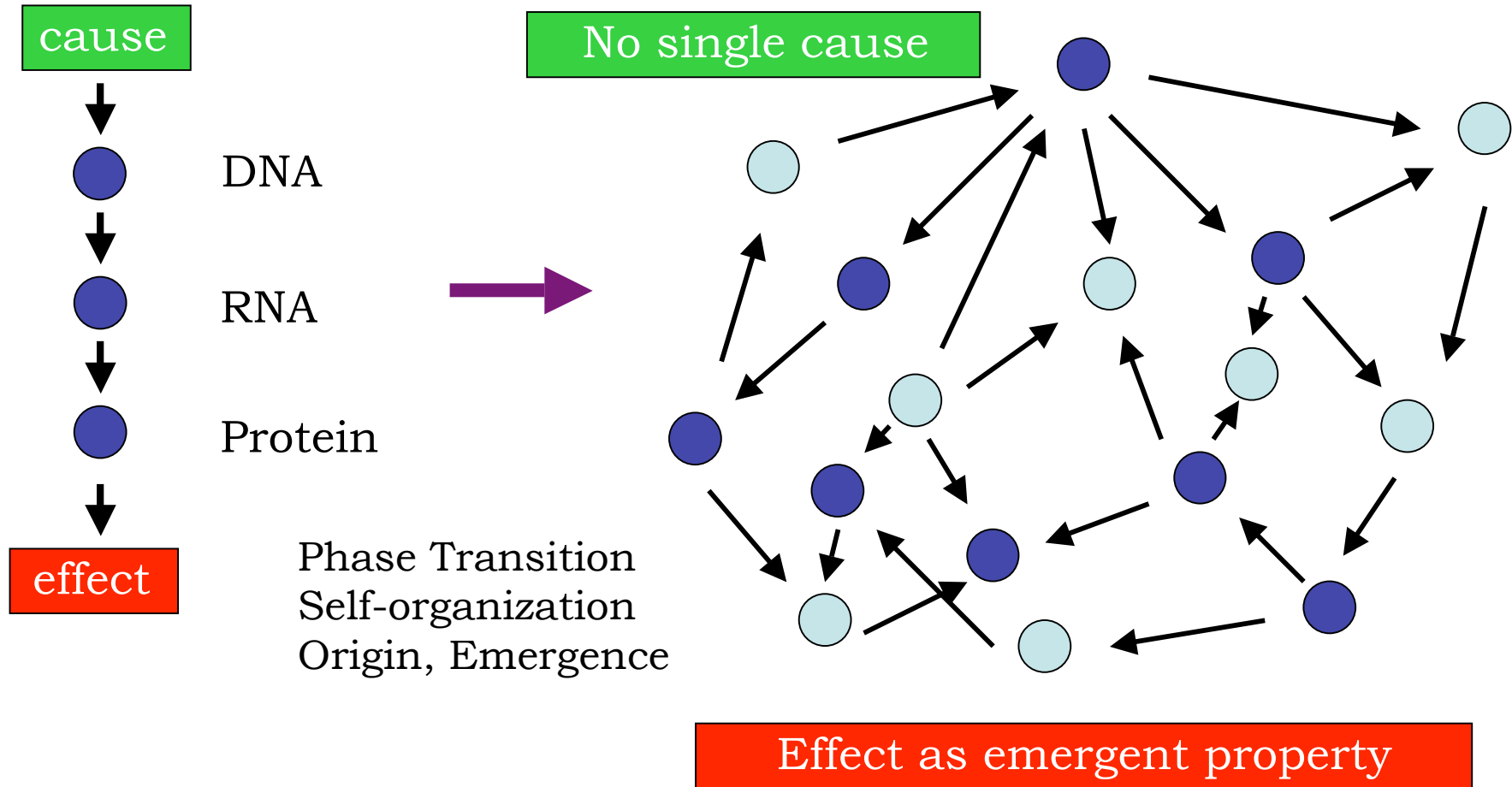


What is Life?

- Endo-exo (or self-nonself) circulation is a key process of life phenomena, because the opposites are complimentary.



What is the Origin of Life?



C_{RNA} → C_{DNA} → RNA → Protein

THE RNA WORLD



Edited by R.F. Gesteland & J.F. Atkins

Cold Spring Harbor  Laboratory Press

Gesteland & Atkins
(1993)

Another Chicken-and-Egg Paradox

If one accepts the notion of an RNA world, then one is faced with the dilemma of how such a genetic system came into existence.

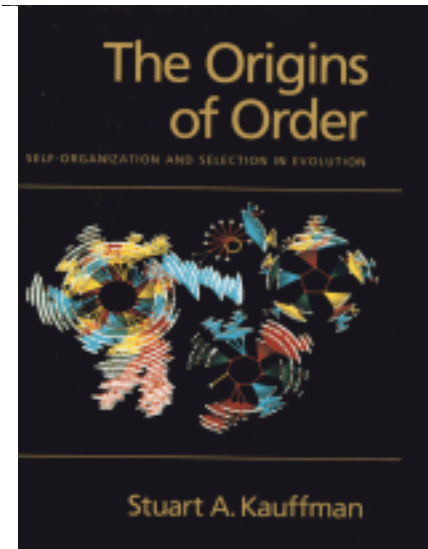
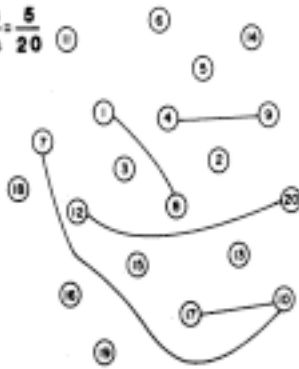
...

Here we encounter another chicken-and-egg paradox: **Without evolution it appears unlikely that a self-replicating ribozyme could arise, but without some form of self-replication there is no way to conduct an evolutionary search for the first, primitive self-replicating ribozyme.**

G. F. Joyce and L. E. Orgel

Origin of the RNA world p13

Edges: 5
Nodes: 20



Self-organized
criticality



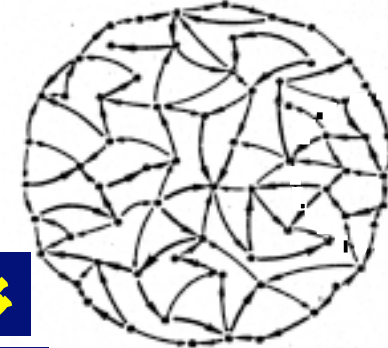
出所: <http://www.mediamatic.net/artefact-227-en.html>

出所: http://digitalarts.lcc.gatech.edu/unesco/biotech/scientists/bio_s_kauffman.html



相轉移

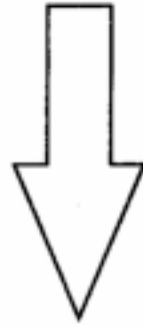
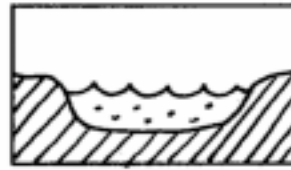
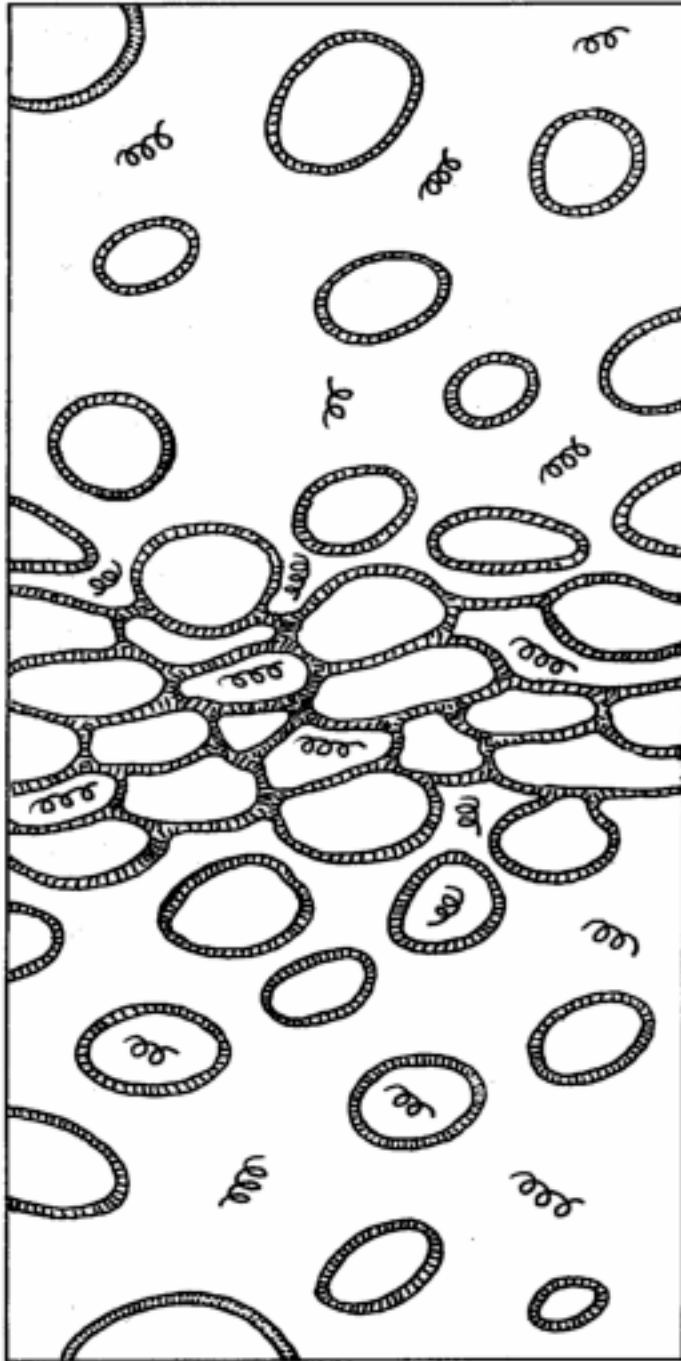
$L \rightarrow L_0$



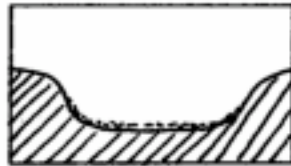
Network open to exo-wold

Molecular Evolution

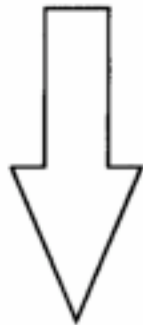
→ Closed network
or Endo-system



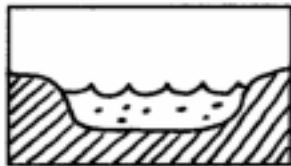
Pool drying



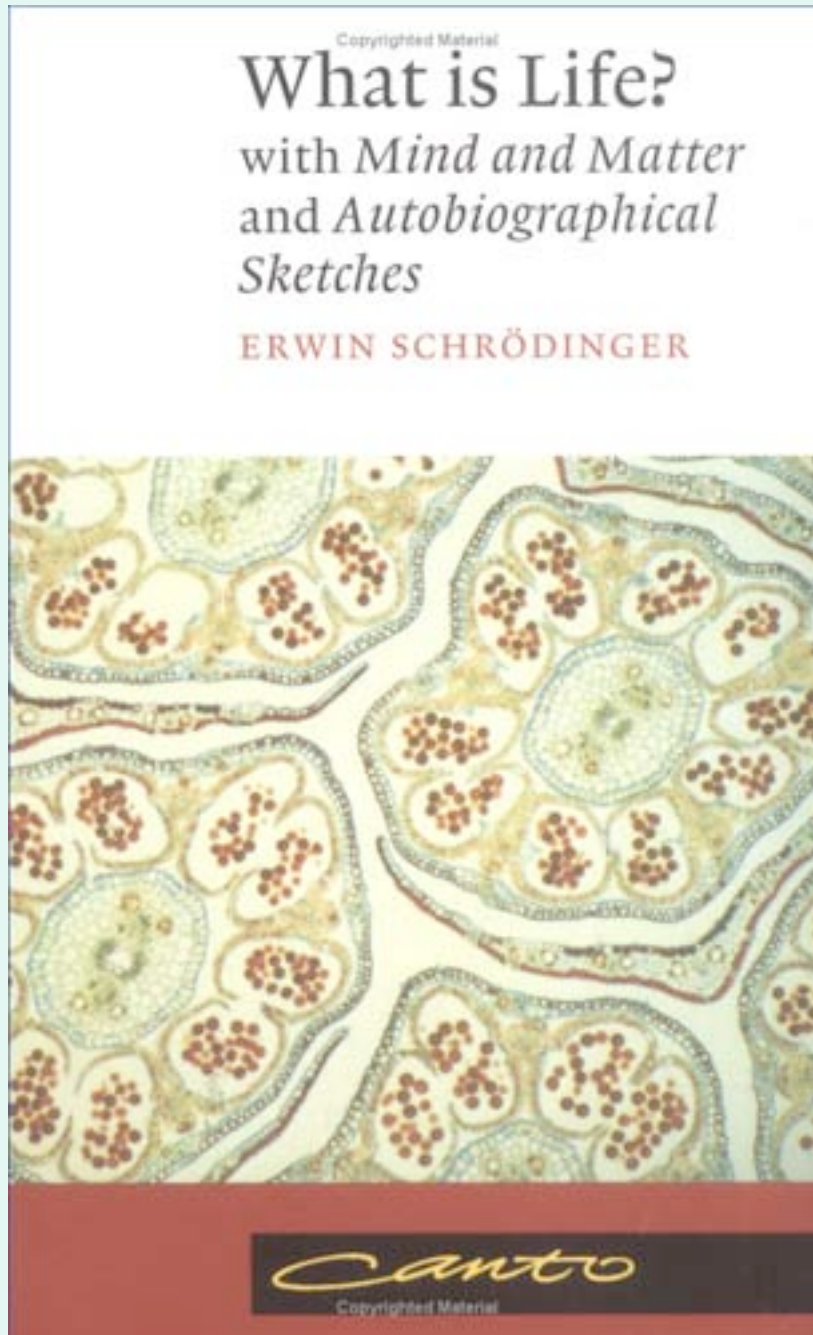
Pool desiccated



Pool rehydrating



On the analogy of N.Bohr's complementary principle, living life and non-living matter are complementary, in which the two opposing aspects being the different states of the same molecules.



Self-replication
is not a key
concept of life.

What is life ?

This long-standing problem has not been solved yet.

This is not because we lack knowledge of molecules such as DNA, but because we lack the principle essential for life.

The origin-of-life problem

It is the central problem of the origin of life, when aggregations of matter obeying only elementary physical laws first began to constrain individual molecules to a functional, collective behavior.

Previous theories assumed

either

(i) polymers

(F.Dyson, M.Eigen, S.Kauffman)

or

(ii) vesicles

(A.Oparin, F.Varela, S.Fox)

in an aqueous solution.

Two major difficulties

- (i) Self-replicating polymers alone never evolve *de novo* out of random polymers without pre-evolving process.
- (ii) Vesicles alone never evolve without stored information based on self-replicating polymers.

I developed a new theory
in two steps

First, I assumed

both

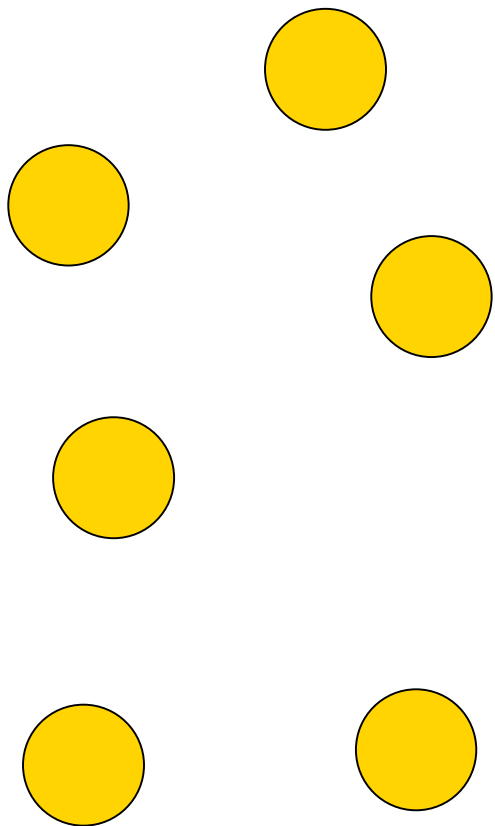
(i) polymers

and

(ii) vesicles

but not always

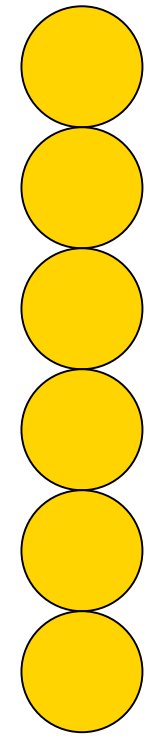
in an aqueous solution.



Monomeric
molecules

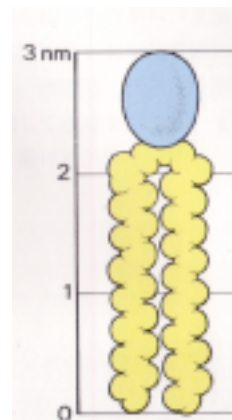


Dehydration



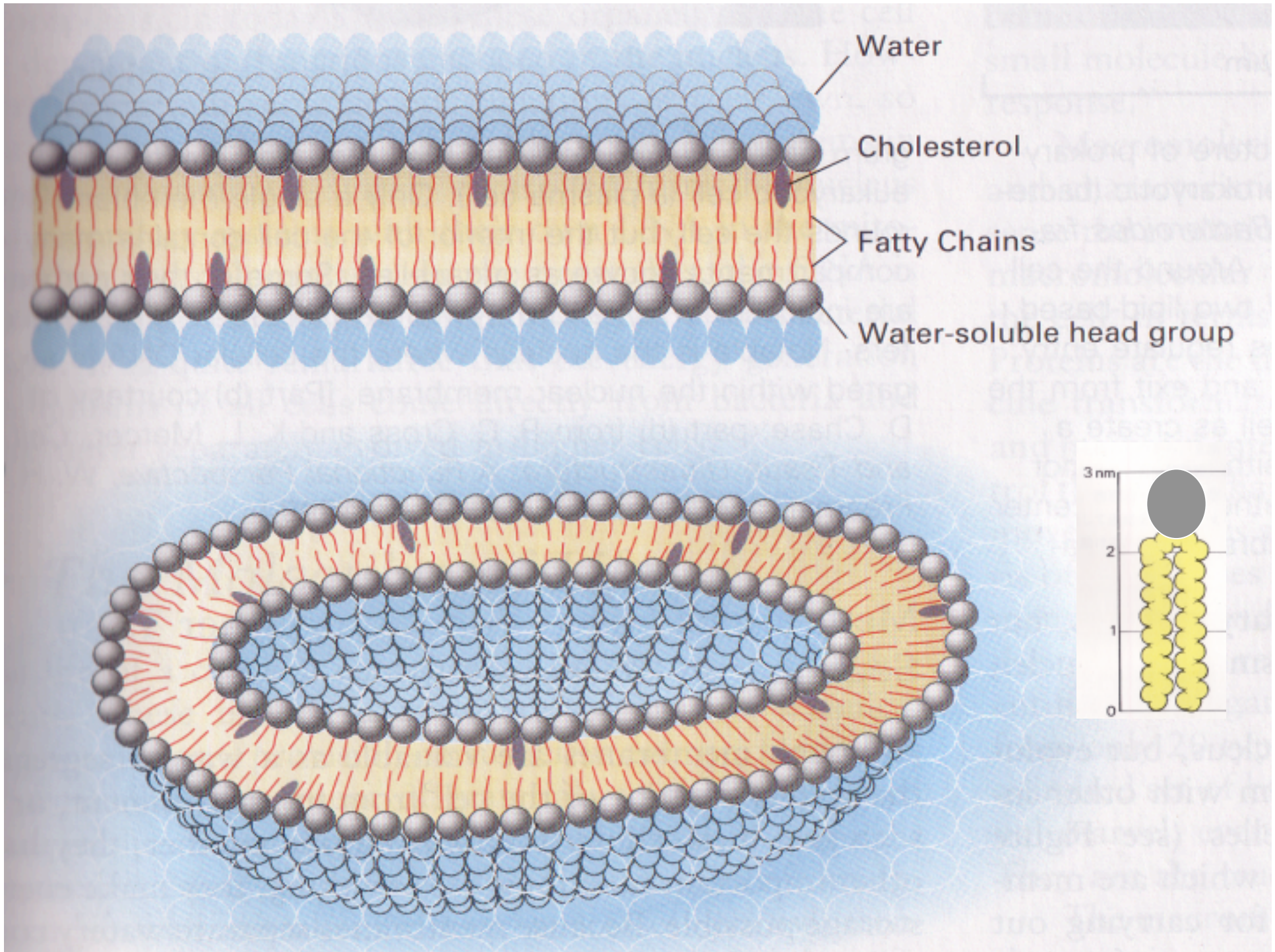
Polymers

Hydrophilic
'heads'



Hydrophobic
'tails'

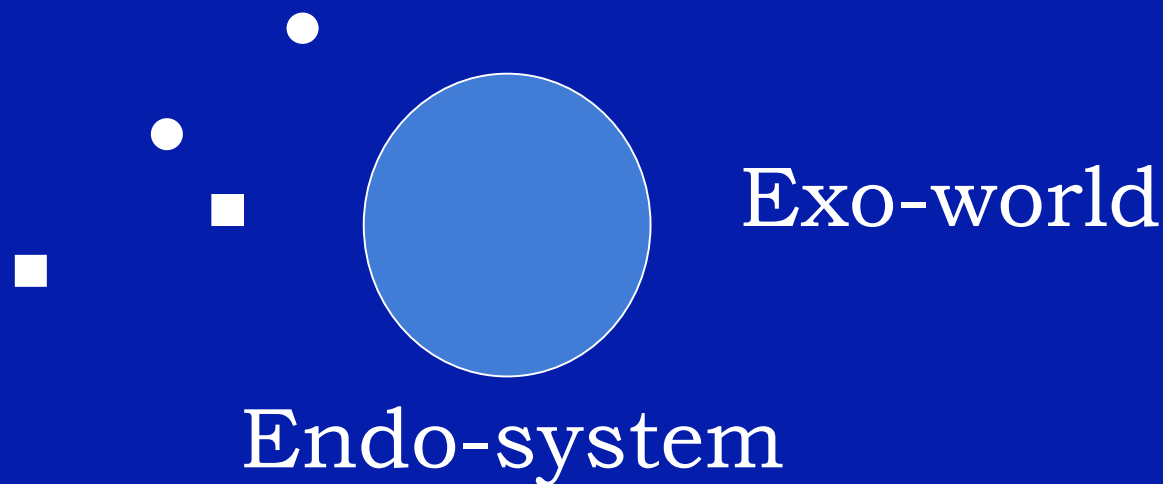
Amphipathic
molecules



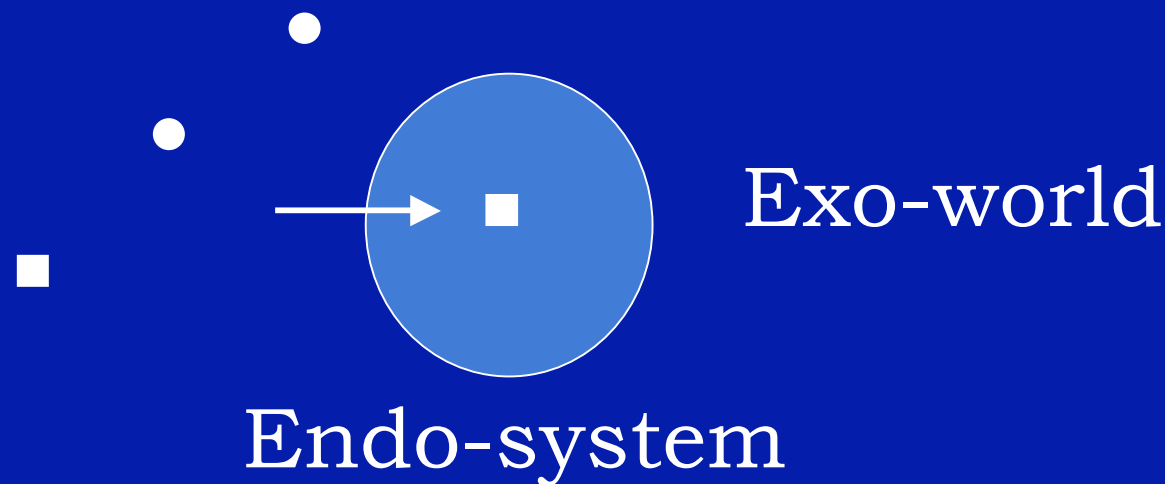
出所: H.Lodish et al. 「Molecular cell biology, W. H. Freeman and Company」 1995 Fig.1.5, p7

Then, I introduced the new principle of endo-exo circulation

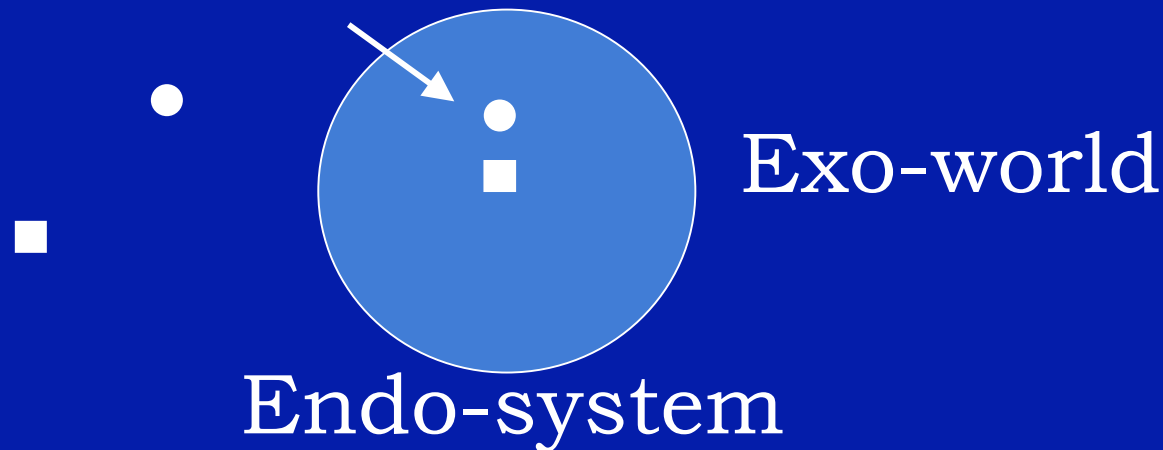
A closed vesicle (or an endo-system) can isolate its identity from the external environment (or the exo-world).



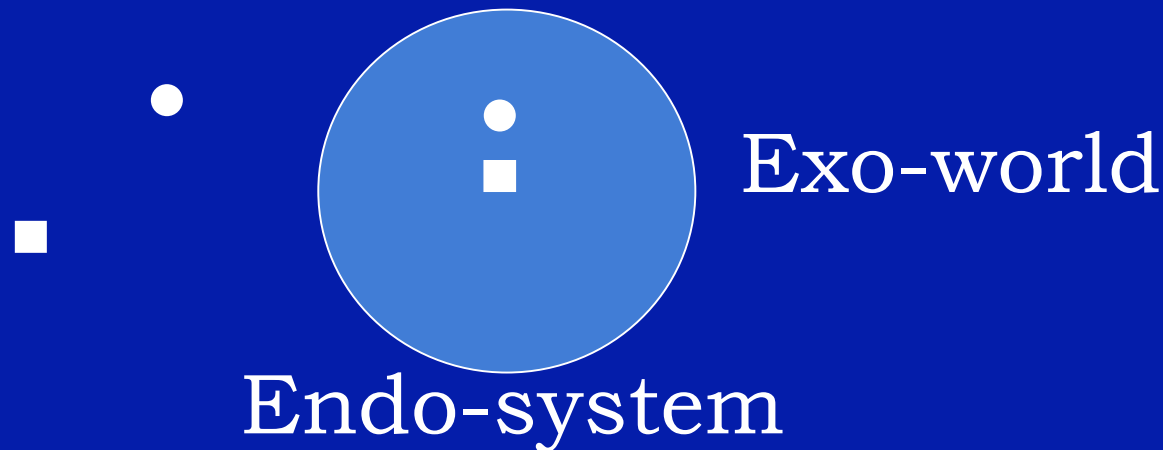
Suppose that such a closed vesicle is subject to assembly-disassembly cycles – that is, the membranes are broken, allowing entry of molecules from the exo-world, and resealed.



At each cycle, the vesicle could not retain the same composition as it was before, but instead evolve due to weak selection through intermolecular interactions.



The enclosed micro-environment can provide a basis for open evolution, because an almost infinite number of molecules are supplied by the exo-world at every cycle.

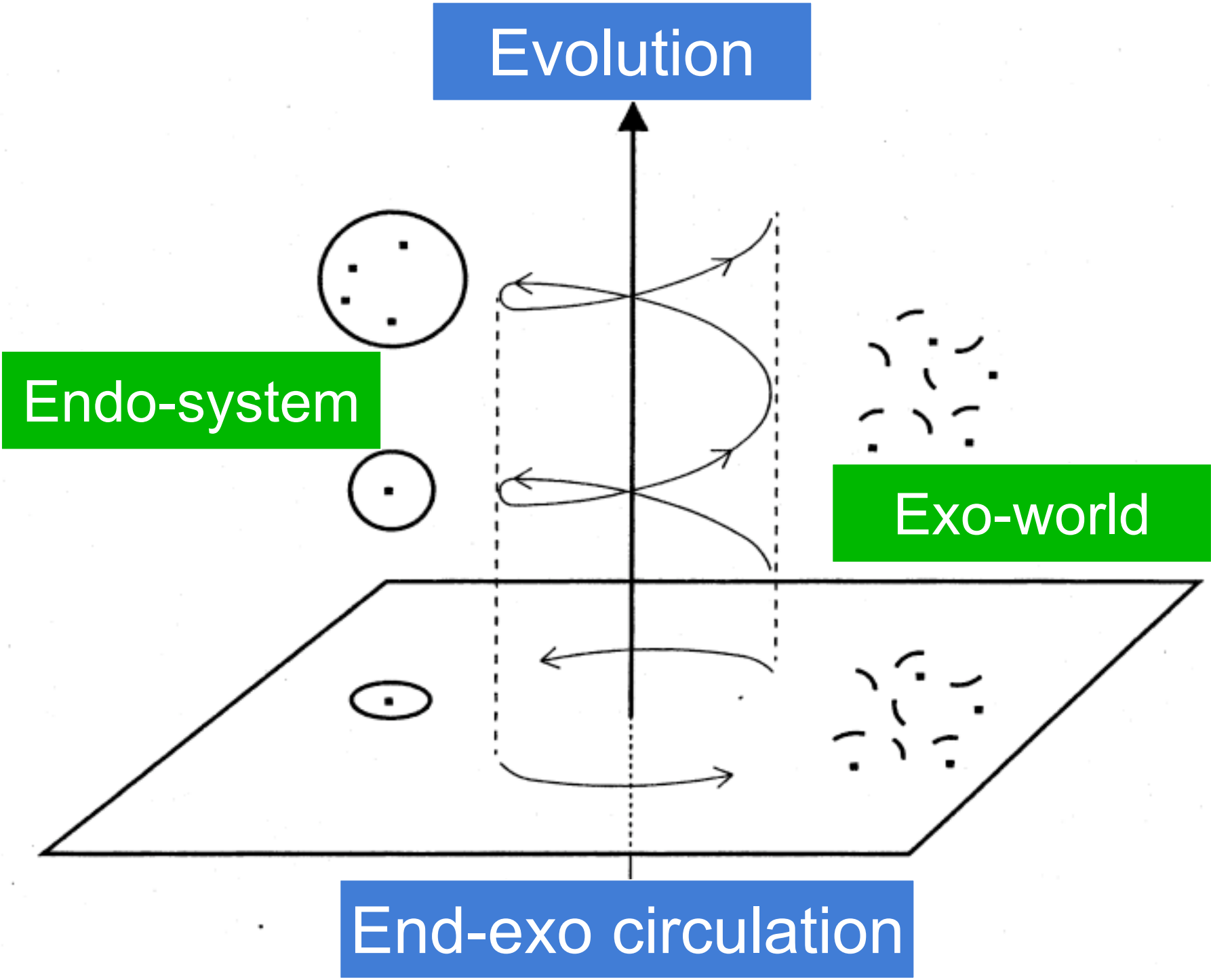


Evolution

Endo-system

Exo-world

End-exo circulation

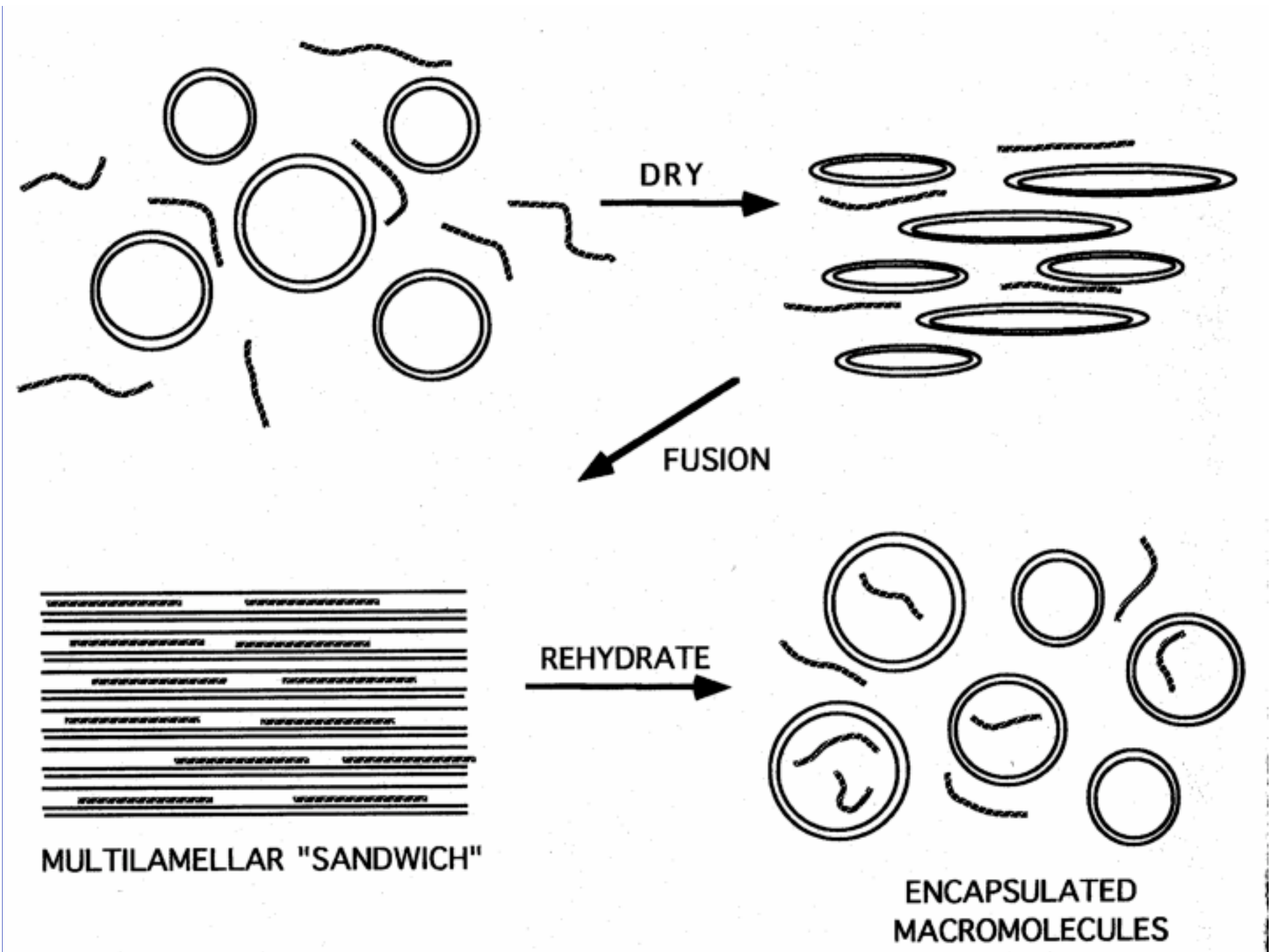


What mechanisms initially drive the endo-exo circulation on the prebiotic Earth ?

Upon **dehydration**,
linear polymers are formed.

Upon **hydration**,
closed vesicles are created.

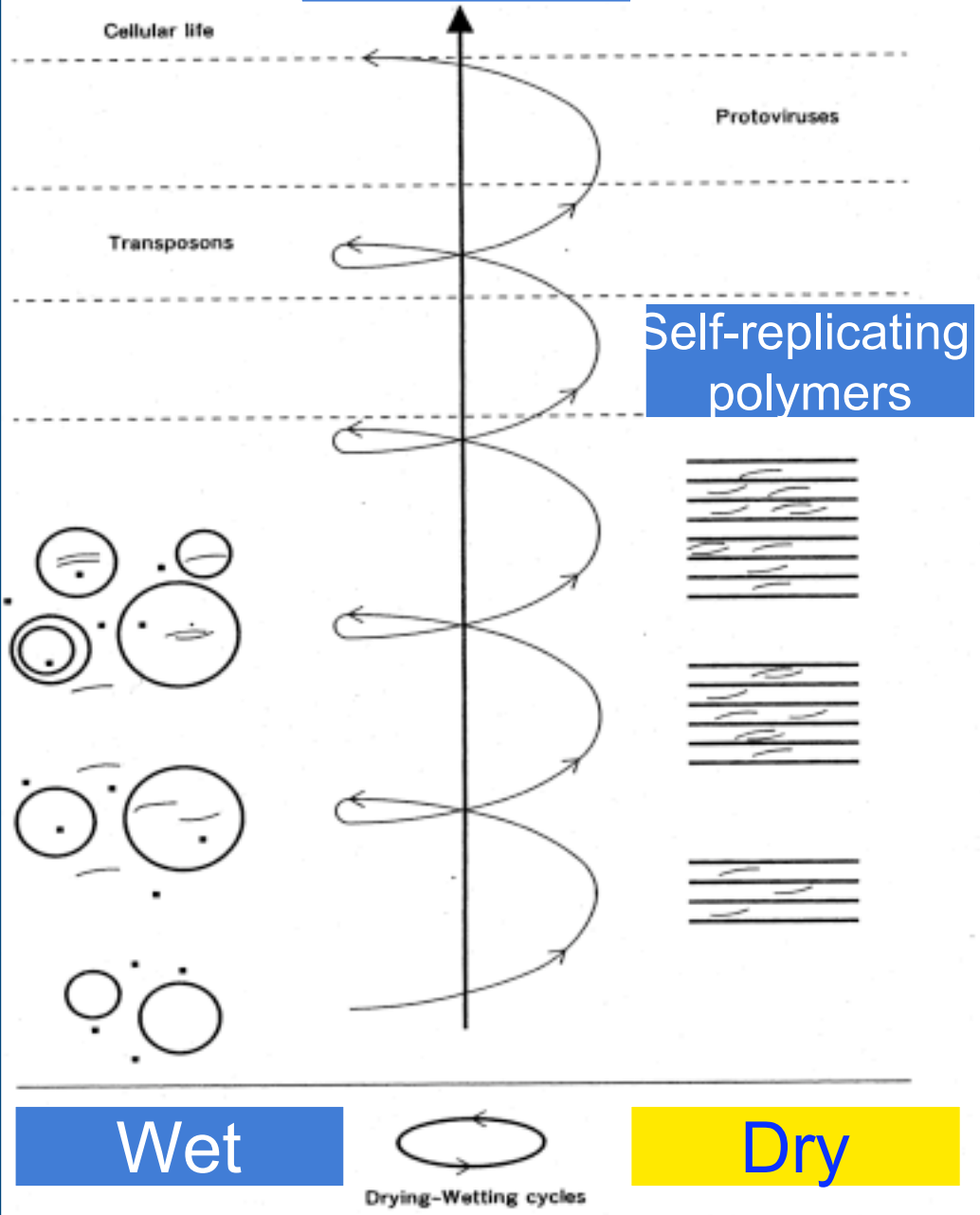
Dehydration-hydration cycles can be one of the plausible mechanisms of the endo-exo circulation, by which many different kinds of polymers and vesicles are alternately **generated** and **degenerated**.



How dose evolution occur ?

Since selection upon pre-existing variability implies evolution, polymers and vesicles would prebiotically co-evolve through endo-exo circulation, if there are two events in a cycle: formation of a great diversity; and selection through molecular interactions.

Evolution



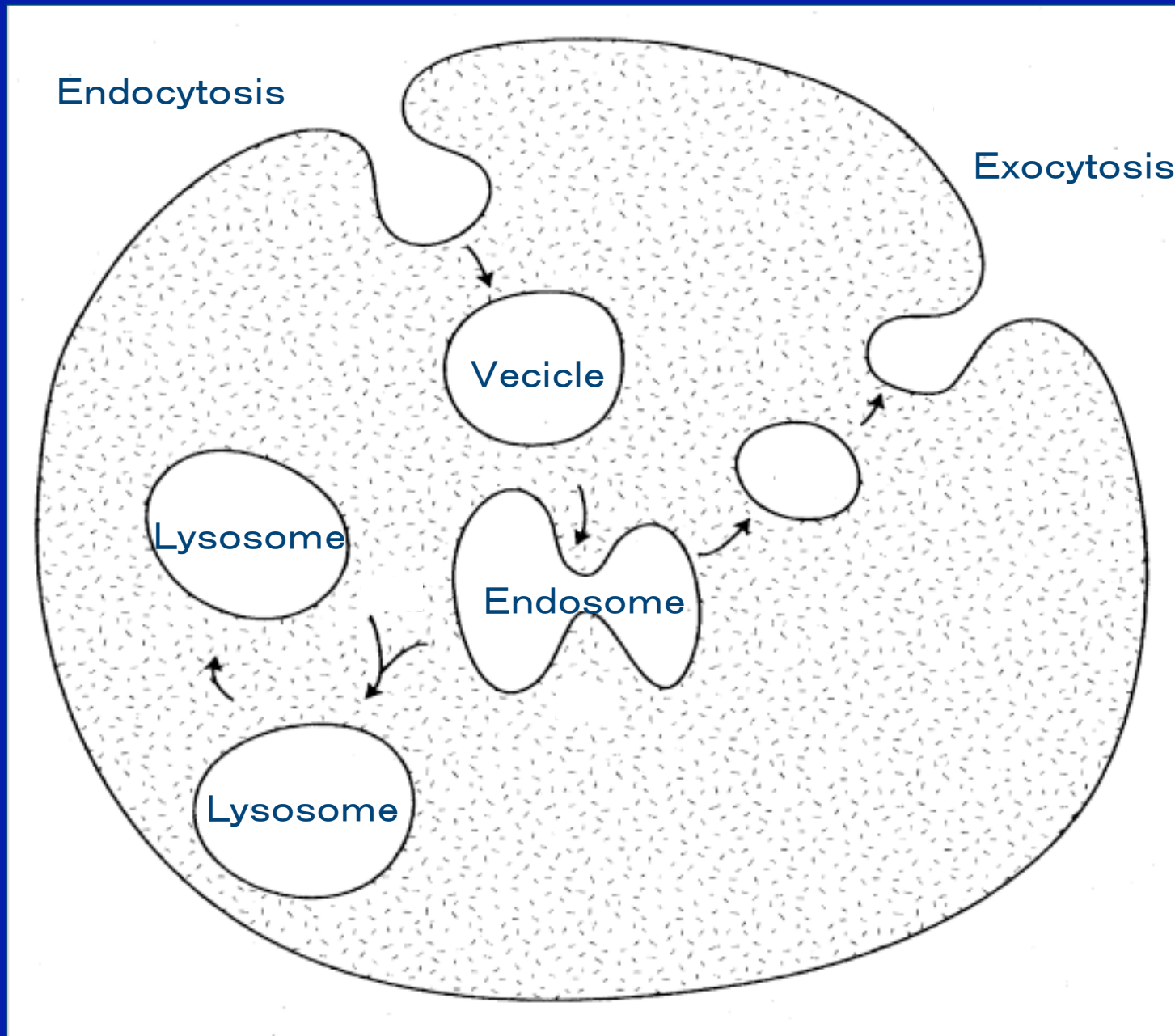
What is the origin of life ?

The origin of life is defined by the events that some autonomous system of endo-exo circulation would arise to take over the outside 'drive'.

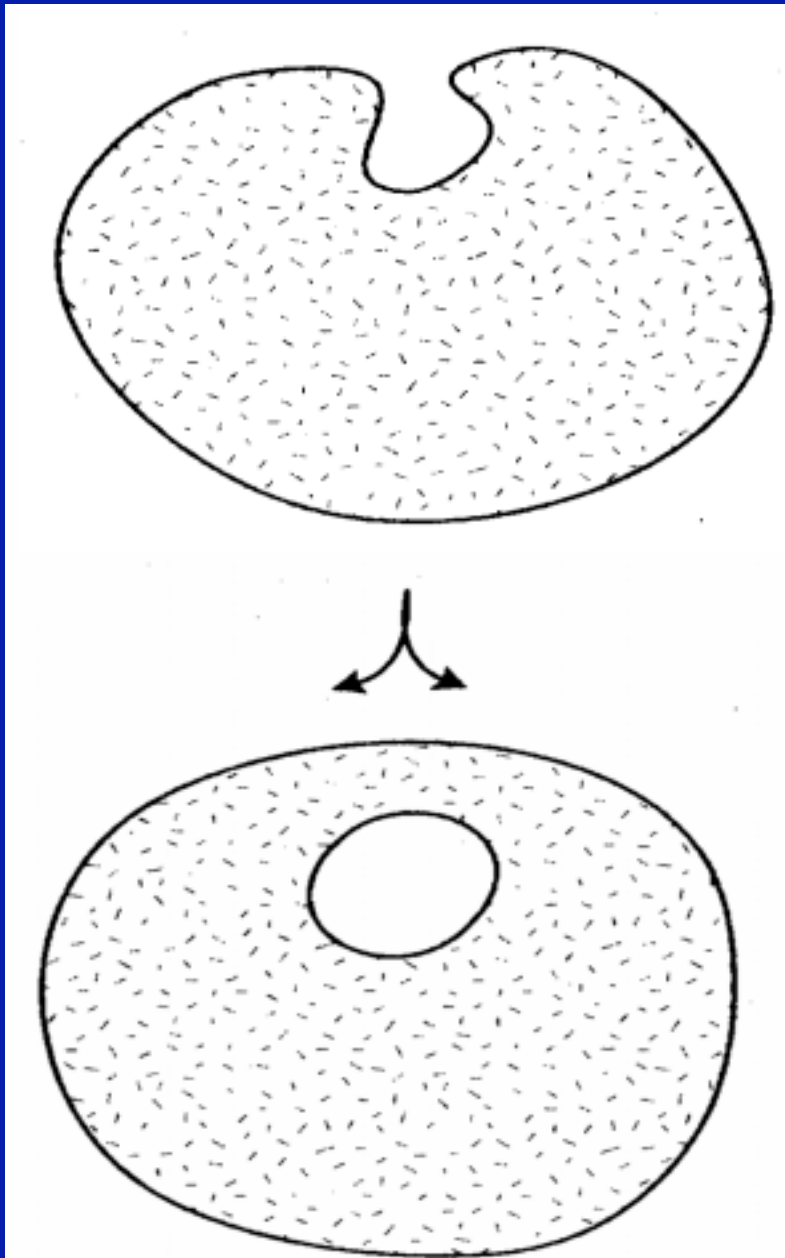
Is the principle of endo-exo circulation universal ?

If the simple principle of endo-exo circulation explains the continuous complexification dynamics, it would govern a wide variety of life phenomena such as **intra-**, **inter-**, and **trans-**cellular organization typical of present-day life.

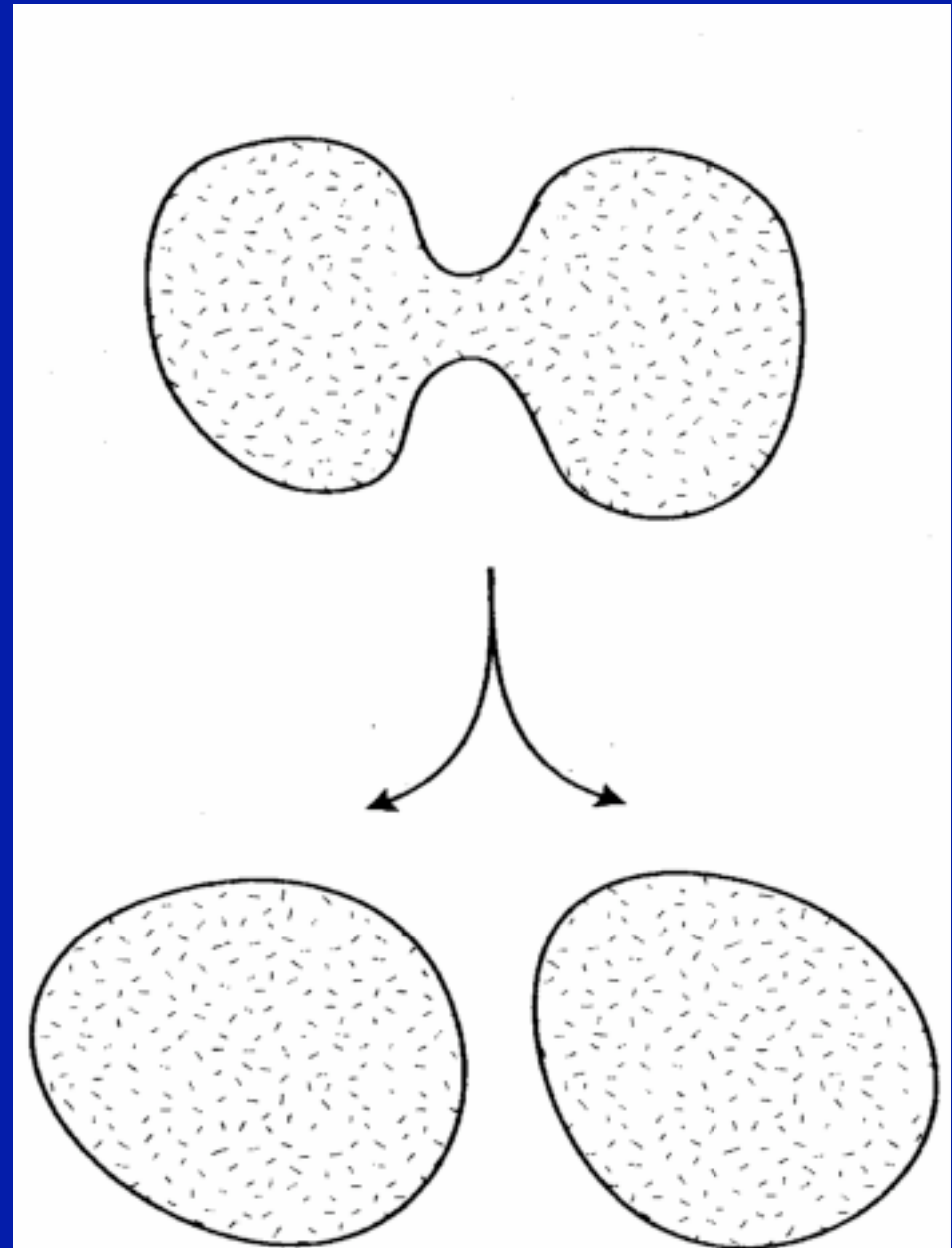
Intra-cellular vesicles



Vesicle formation



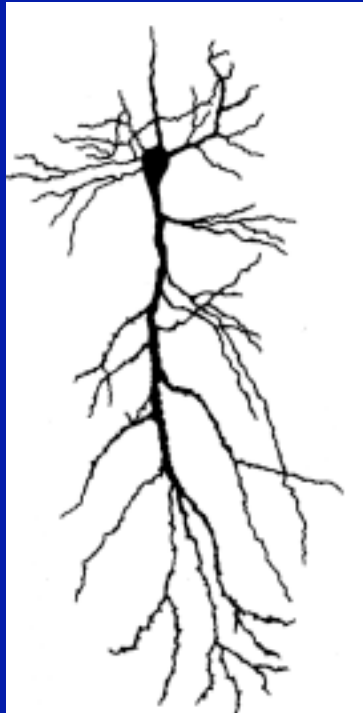
Cell division



Is the principle of endo-exo
circulation universal ?

Let us consider trans-cellular
organization.

Like the 'life and matter' problem,
the 'mind and body' problem may
be solved through the endo-exo
circulation.



12345

Clear-cut top

345

12

34

Bottom

1

2

3

4

5

12345

123

234

345

12

23

34

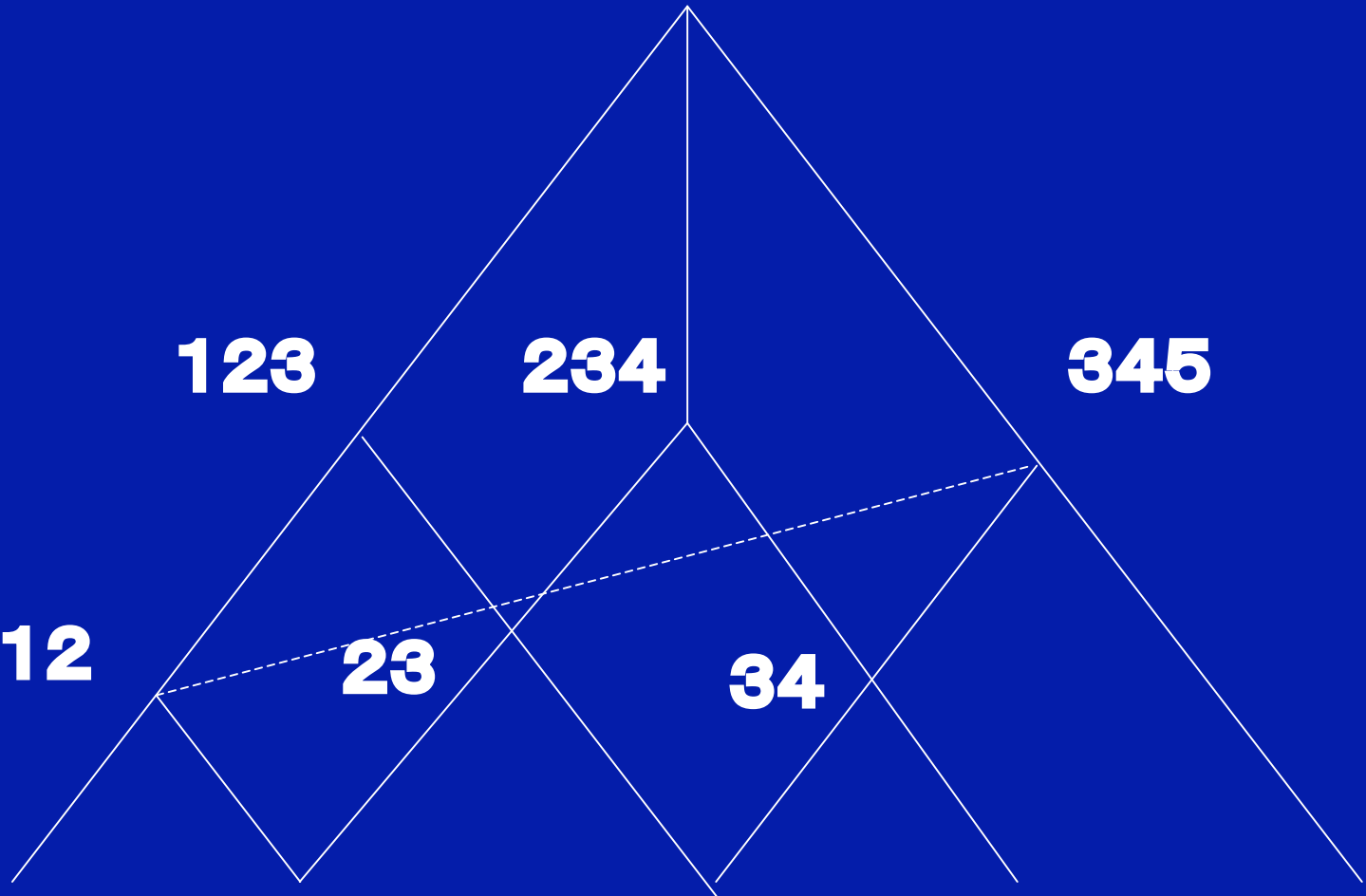
1

2

3

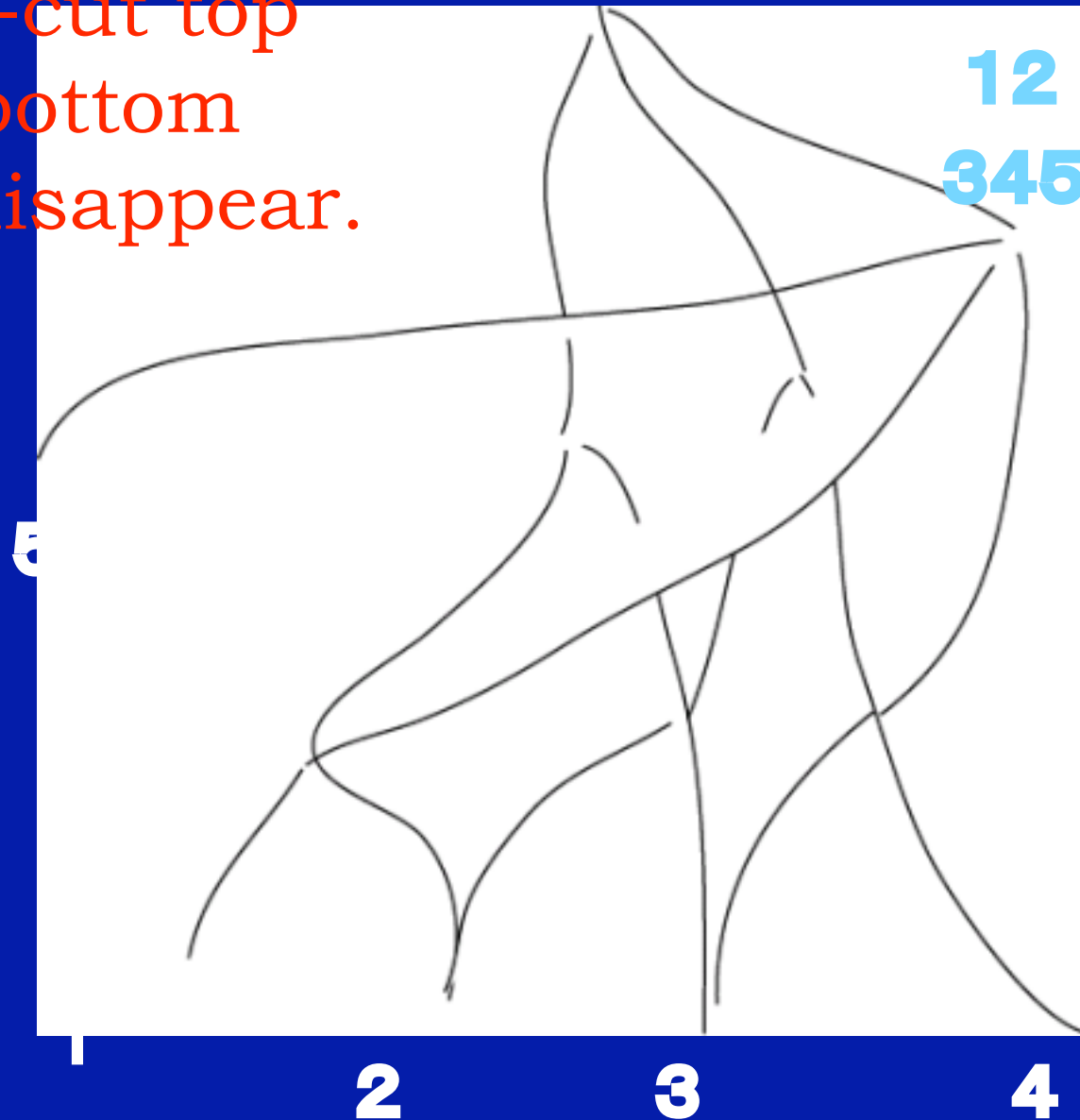
4

5



12345

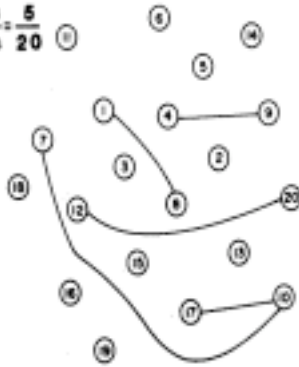
Clear-cut top
and bottom
will disappear.



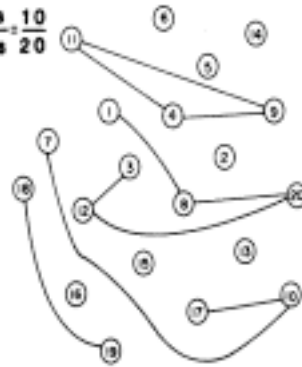
The emergence of endo-system

As the number of dendrites increases and exceeds a certain level of complexity with little change in the number of nerve cells, the emergence of drastic change can occur.

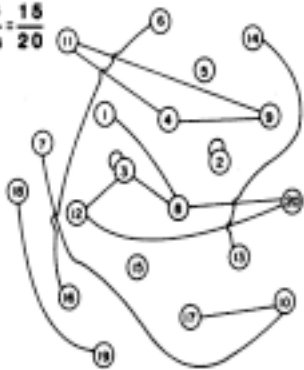
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Nodes = 20



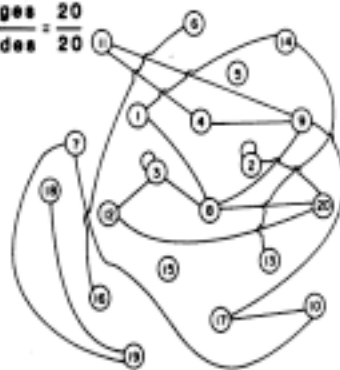
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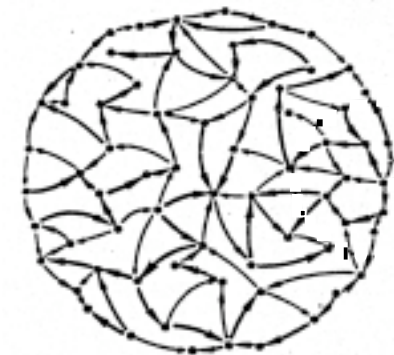
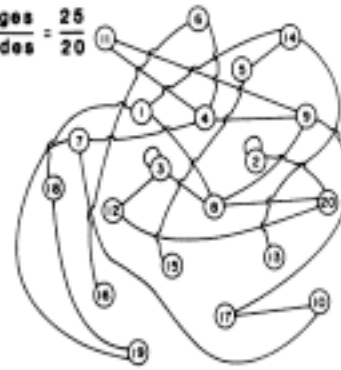
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Nodes = 20



Edges = 20
Nodes = 20

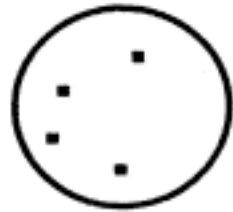


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Nodes = 20

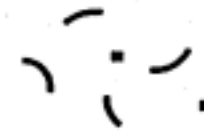
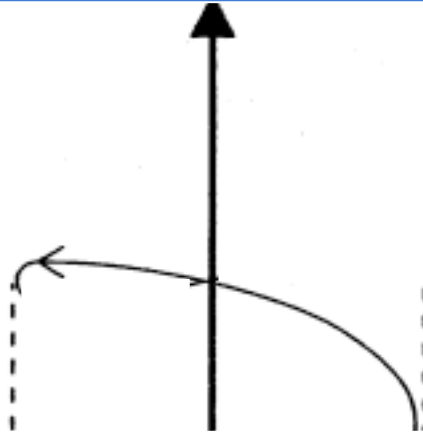


Network open to exo-world → Closed network or Endo-system

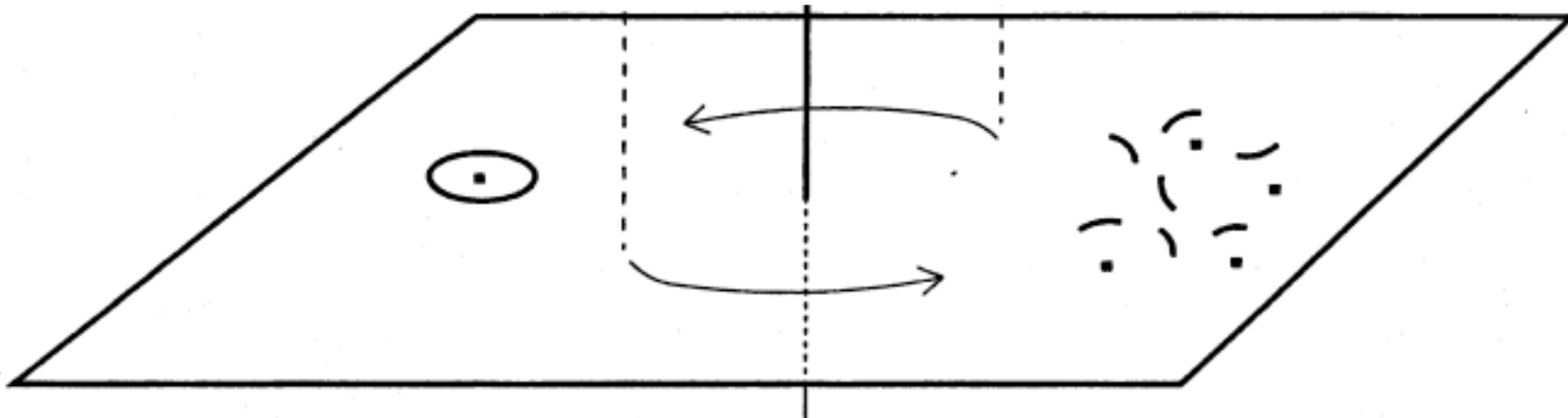
Evolution



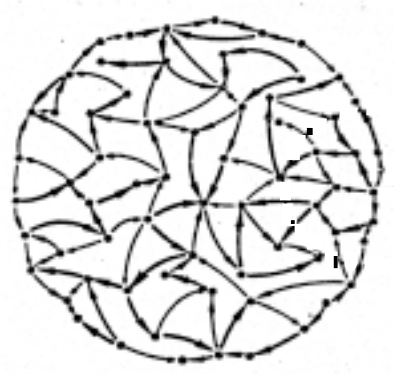
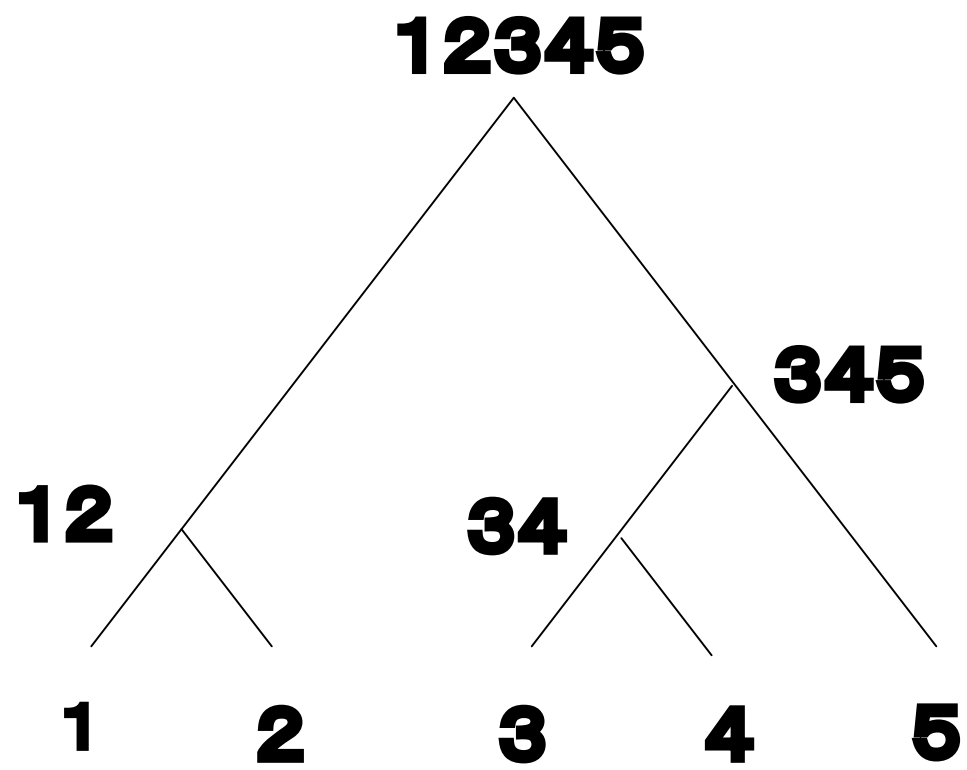
Endo-system



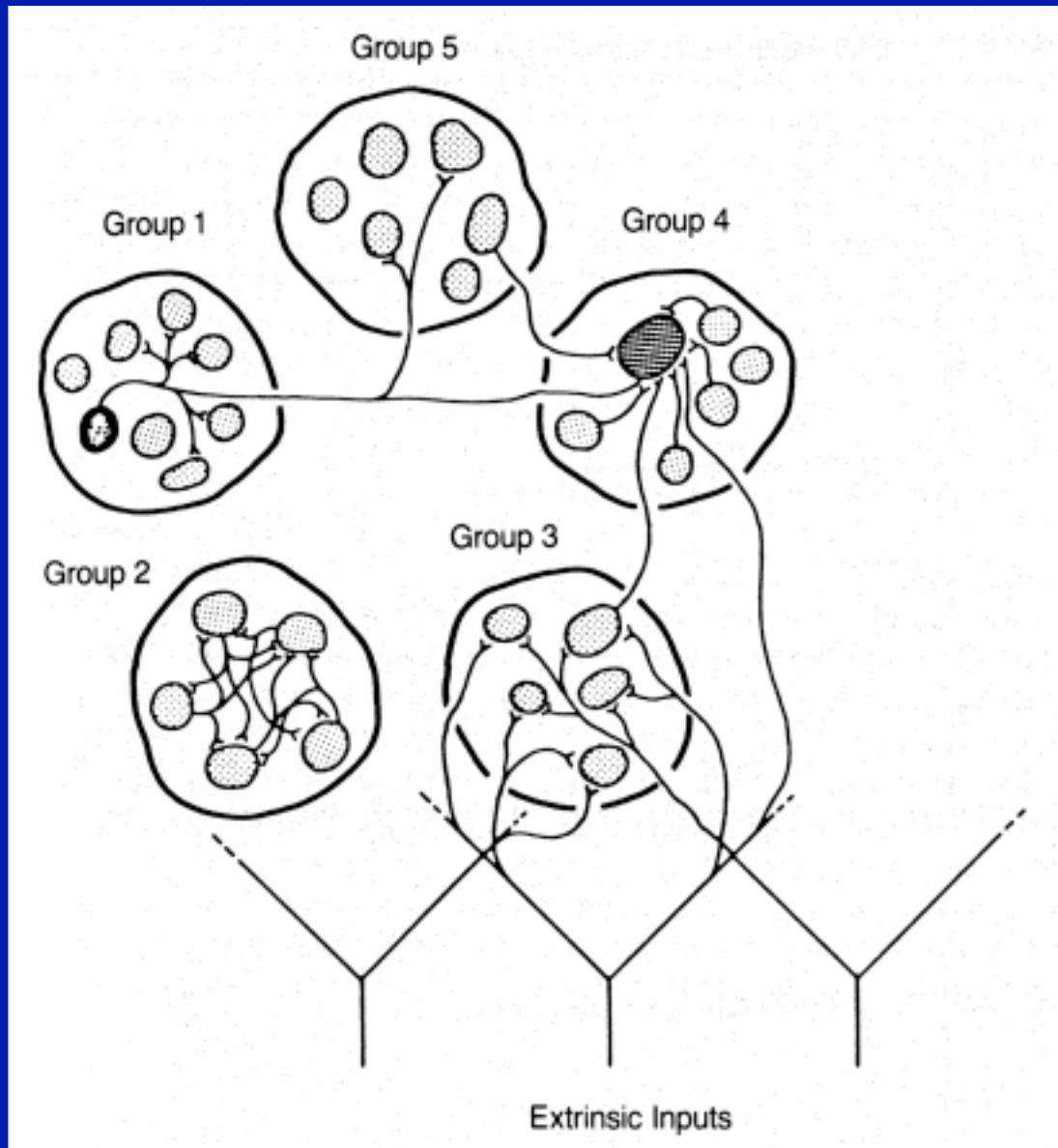
Exo-world

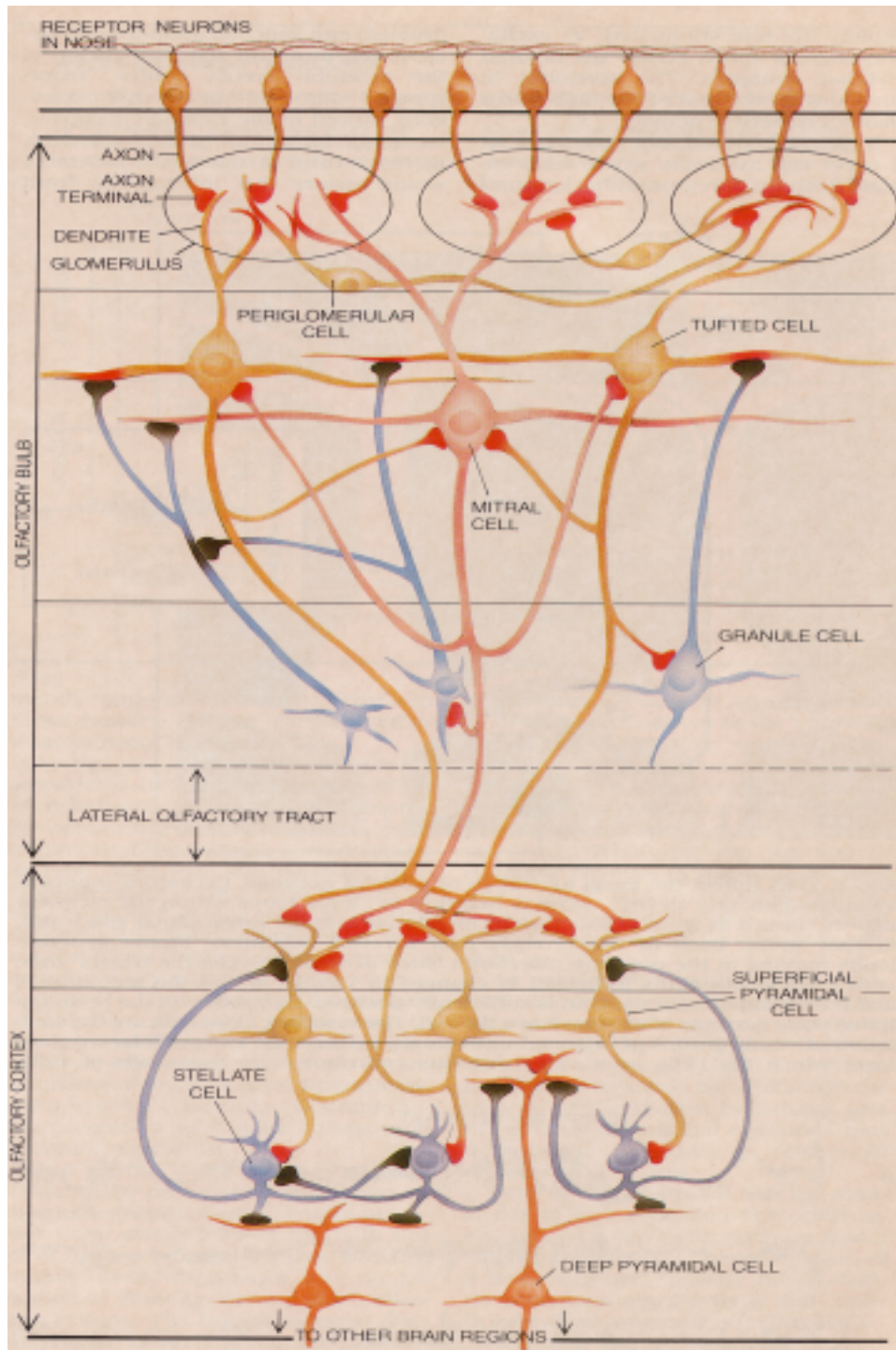


End-exo circulation



Group networks open to exo-world → Closed network or Endo-system





Although inputs from the exo-world perturb the endo-system, the control of this system is embodied within itself.

Just as life emerges from the matter, mind seems to emerge from the body.

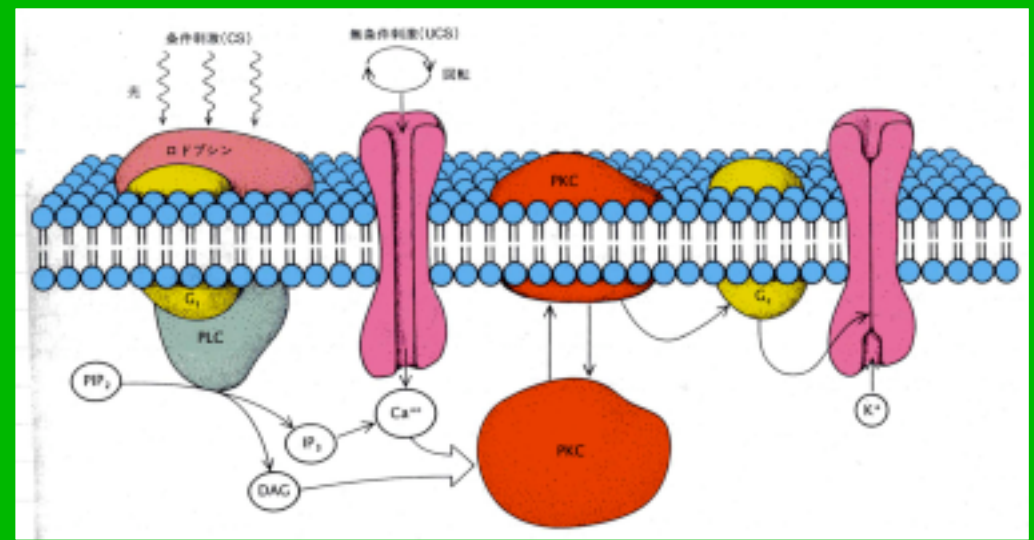
The endo-exo circulation as scale-invariant principle

Life-matter problem and Mind-body problem

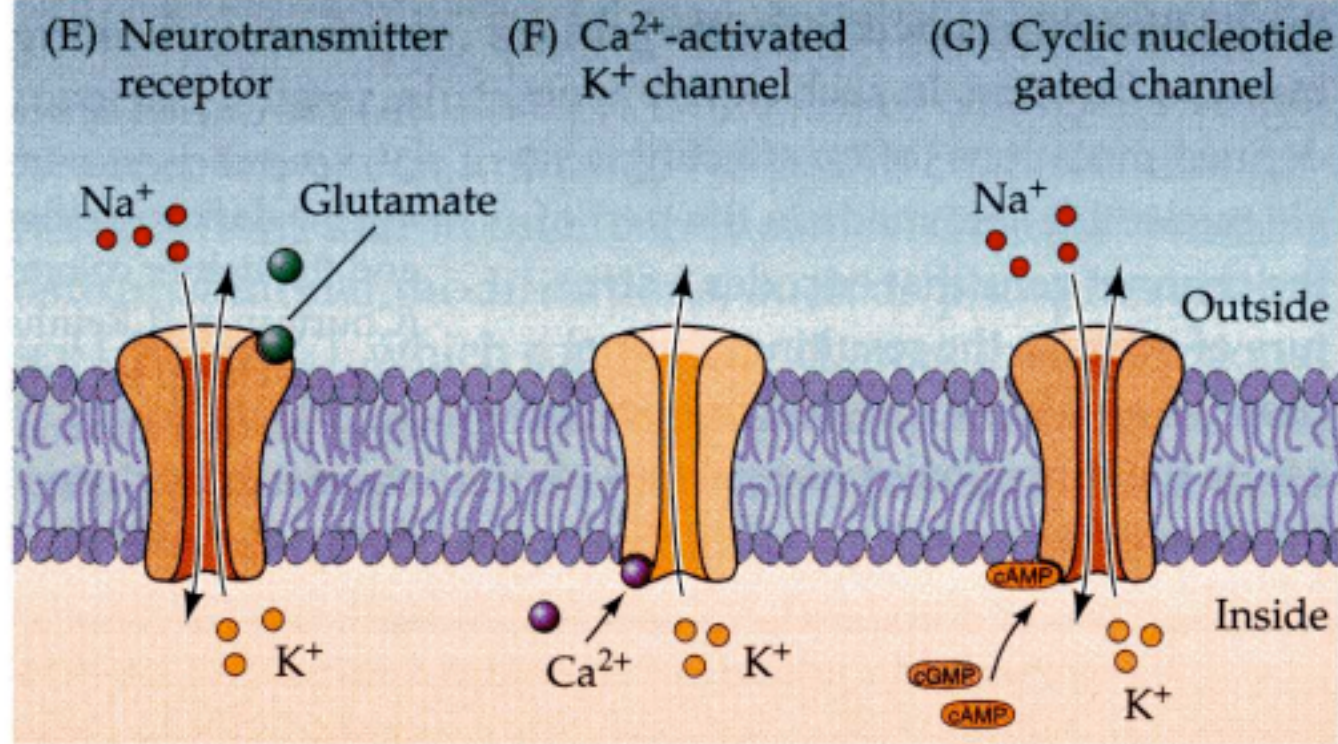
It is not the self-replication but the endo-exo circulation that could cause the continuous complexification of initially non-living matter towards the origin of life and the origin of mind.

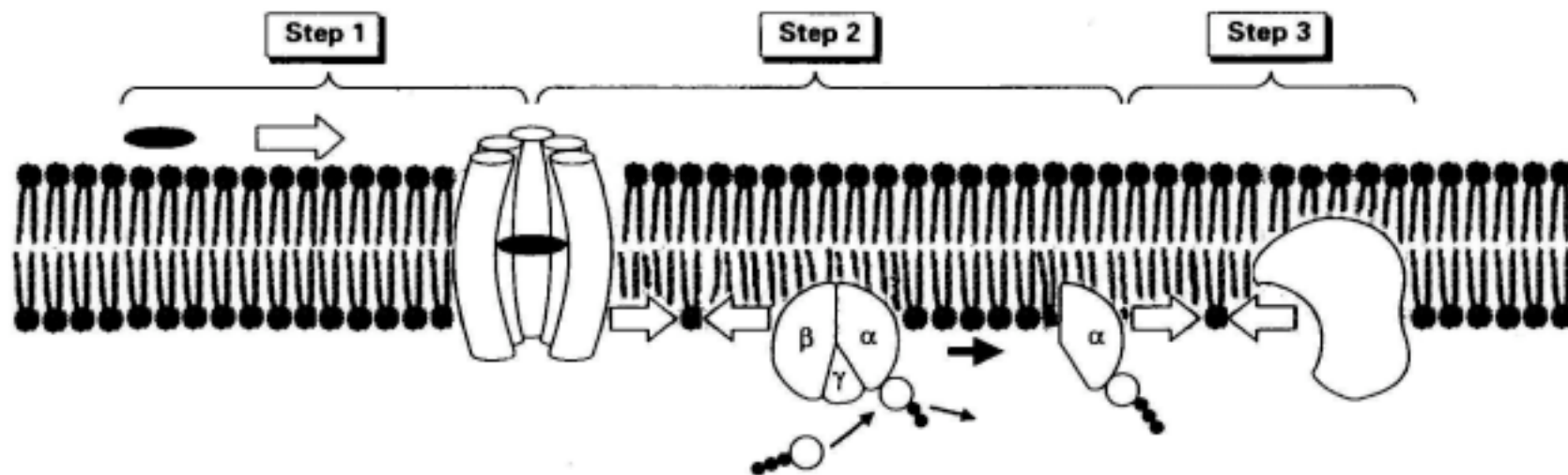
Acute response with nongenomic action
 Chronic response with genomic action

sec min hour year



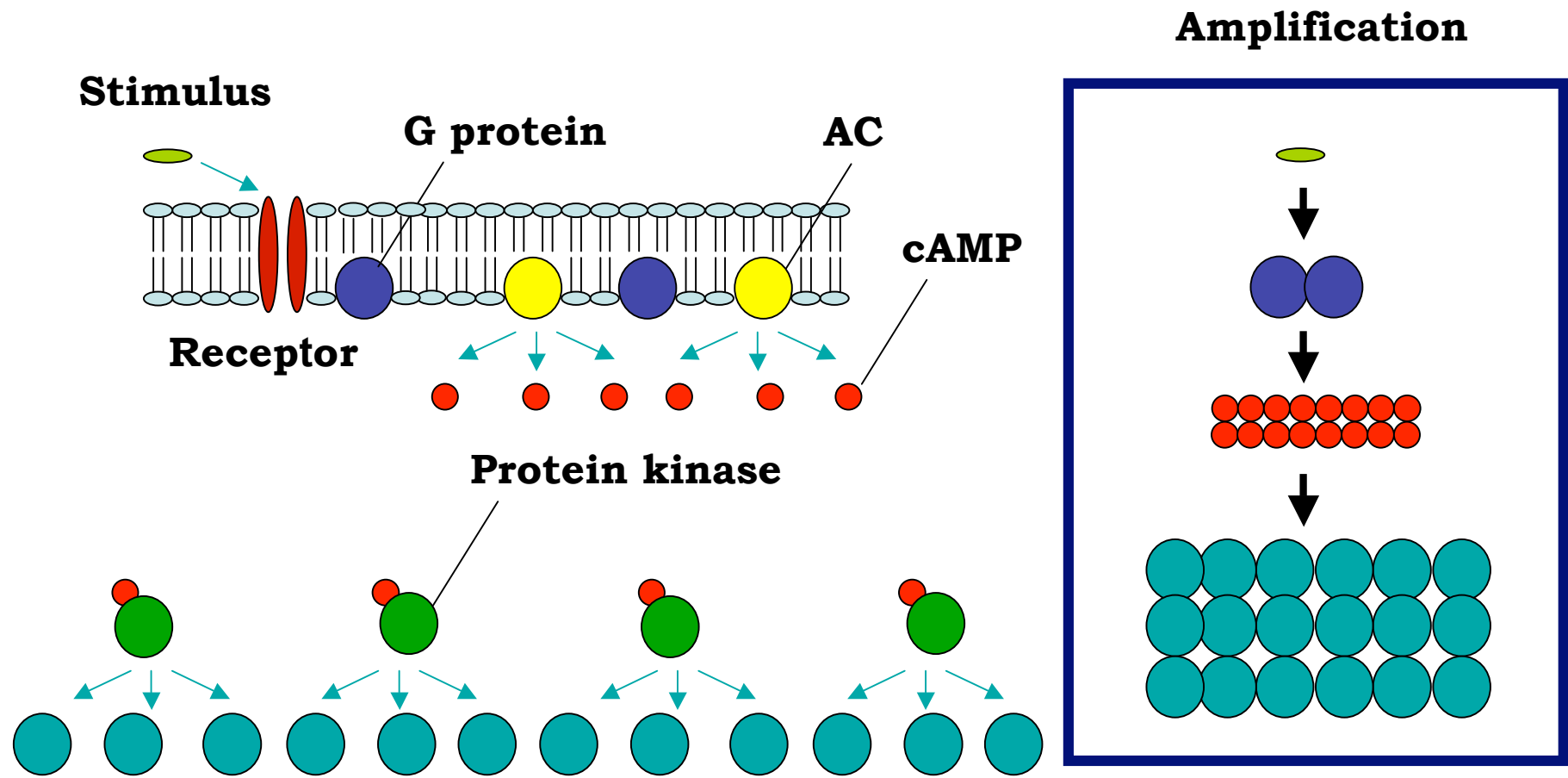
LIGAND-GATED CHANNELS





S	R*	G	G*	E
Stimulus	Receptor	G protein		Effector
1. photon	rhodopsin	G_T		PDE
2. odorant	olfactory	G_{olf}		AC
3. NAdr	β -adrenergic	G_S		AC
4. ACh	M_2 -muscarinic	G_K		K^+ channel
5. vasopressin	V-1a	G_{PLC}		PLC

Fig. 1. G-protein cascades: activation of the three principal proteins; see text for details. Examples of stimulus, receptor, G protein and effector protein are given for five typical cascades: (1) photoreceptor; (2) olfactory receptor; (3) β -adrenergic receptor; (4) muscarinic receptor; (5) vasopressin receptor.



Stimulus

photon
odorant
Nadr
ACh

Receptor

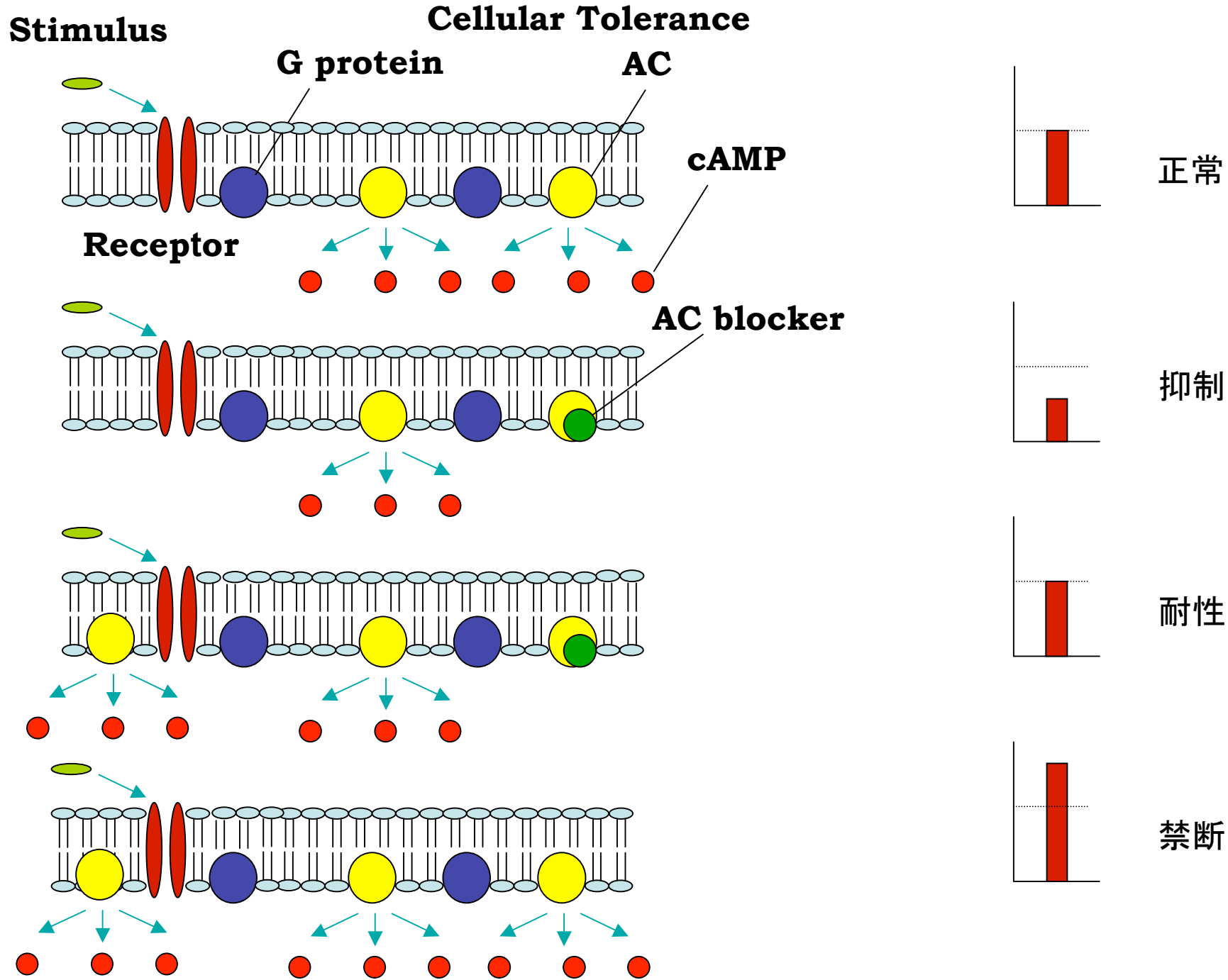
rhodopsin
olfactory
adrenergic
muscarinic

G protein

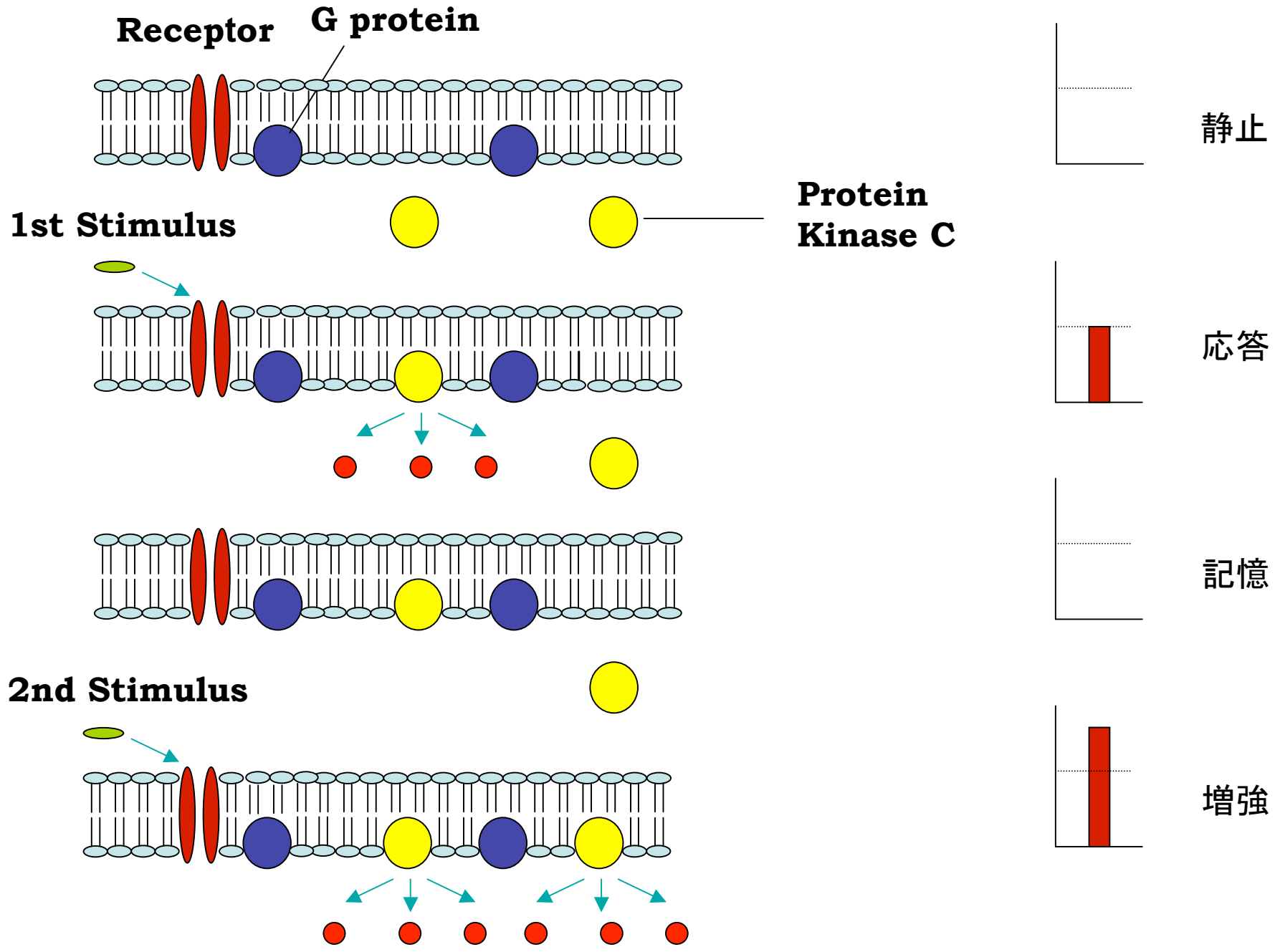
Gt
Golf
Gs
Gk

Effector

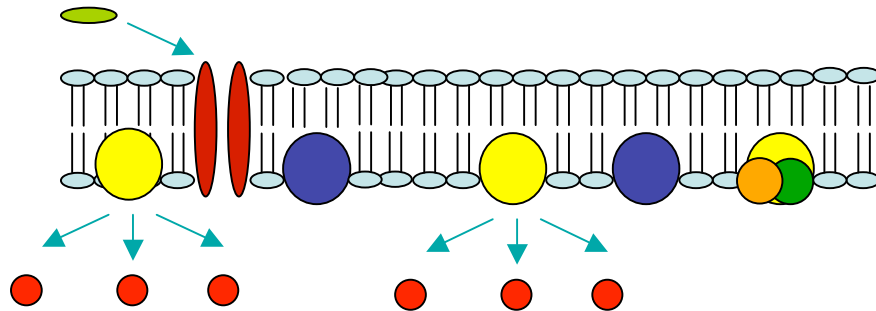
PDE
AC
AC
K-channel



Cellular Memory



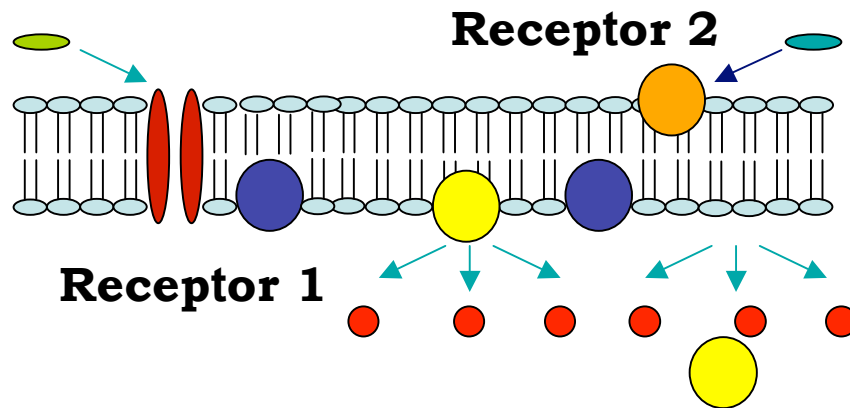
Stimulus



交叉耐性:
1つの薬剤に耐性になると別の薬剤にも耐性になる。

Stimulus (UCS)

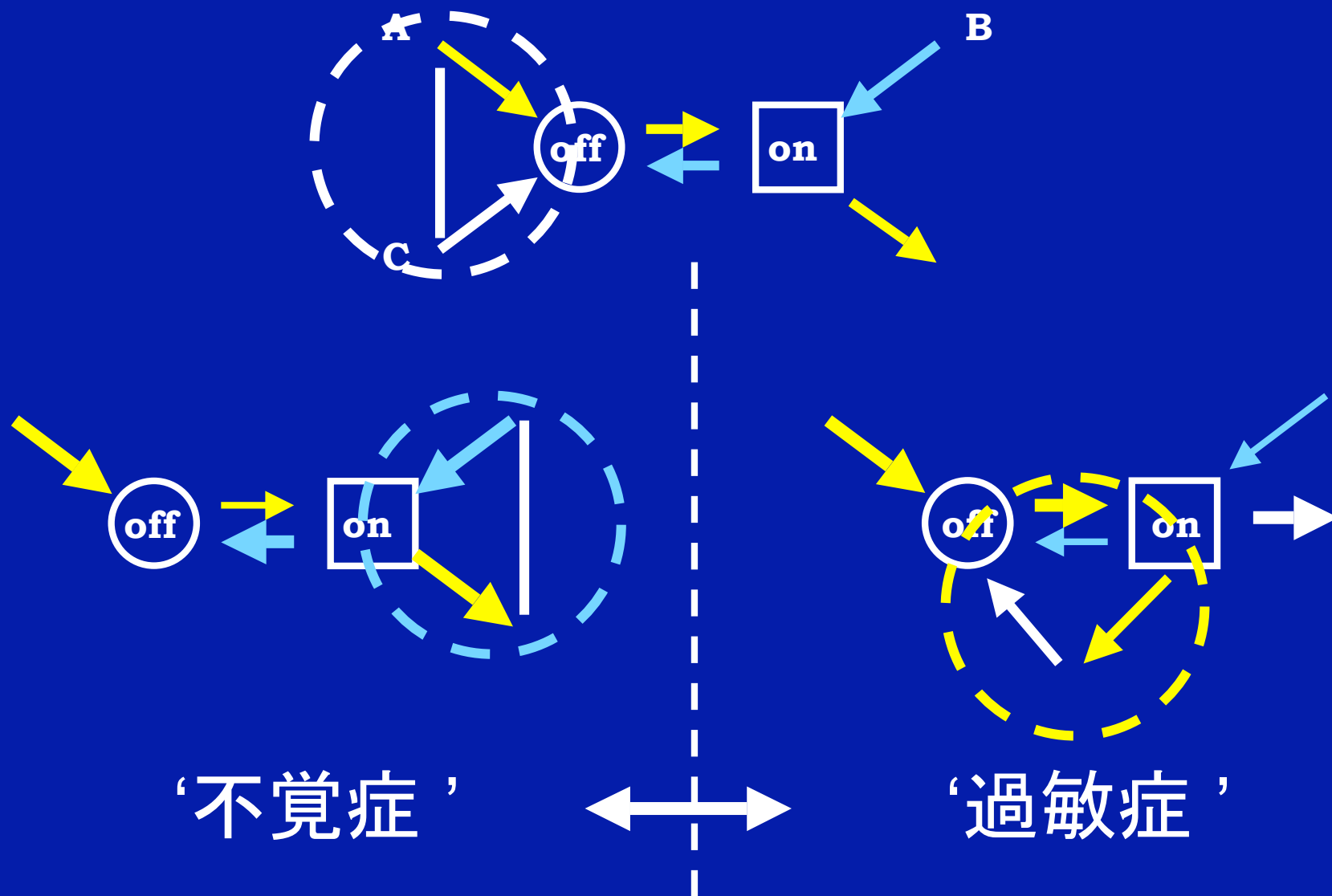
Stimulus (CS)



連合学習:
パブロフの条件付け
2つの刺激の時間間隔に基づく応答の転移。

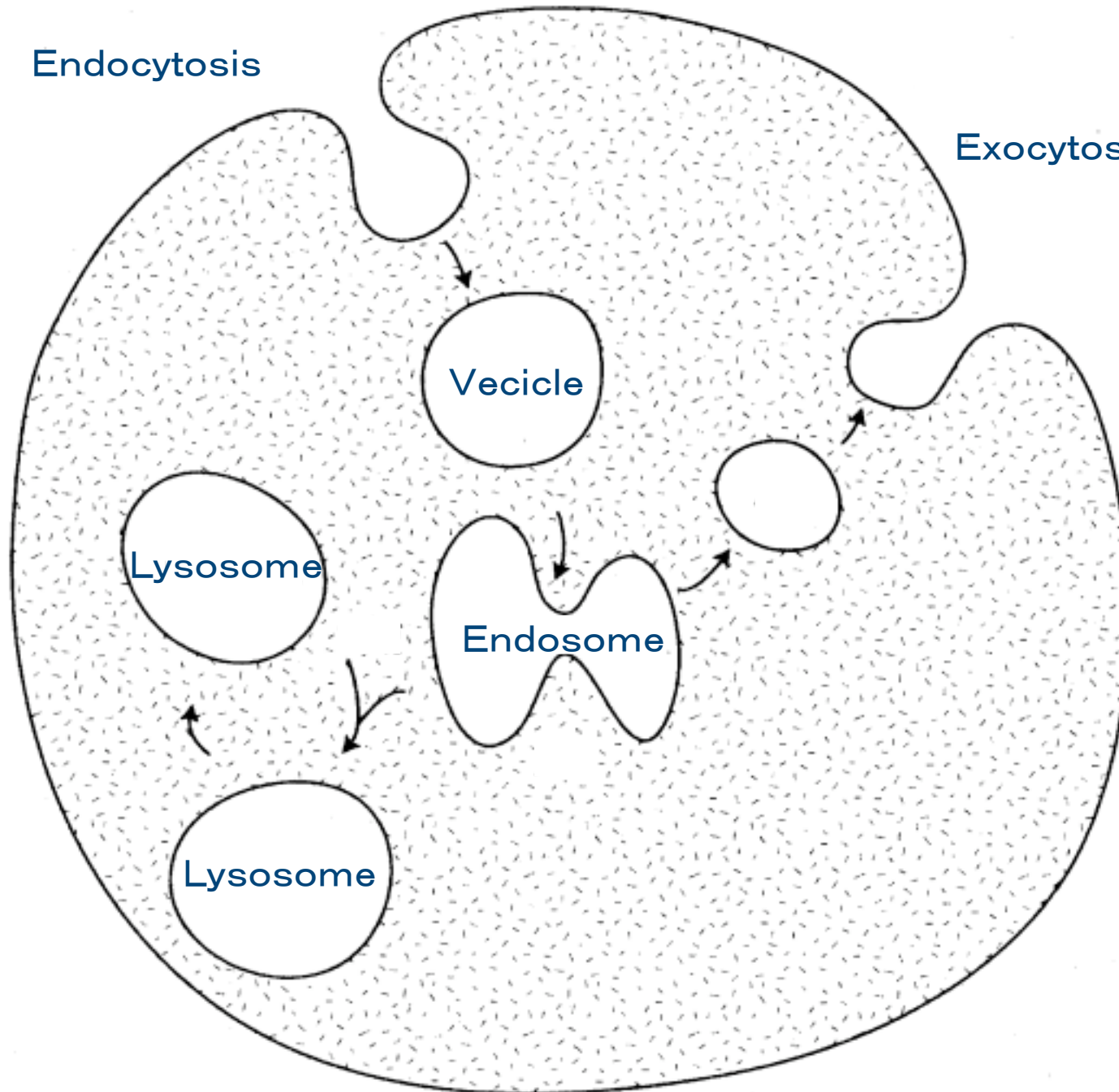
細胞膜の再構成:
調節、記憶、学習、耐性、病気

刺激反応プロセスの内在化としての学習 —パブロフの条件付け連合学習—

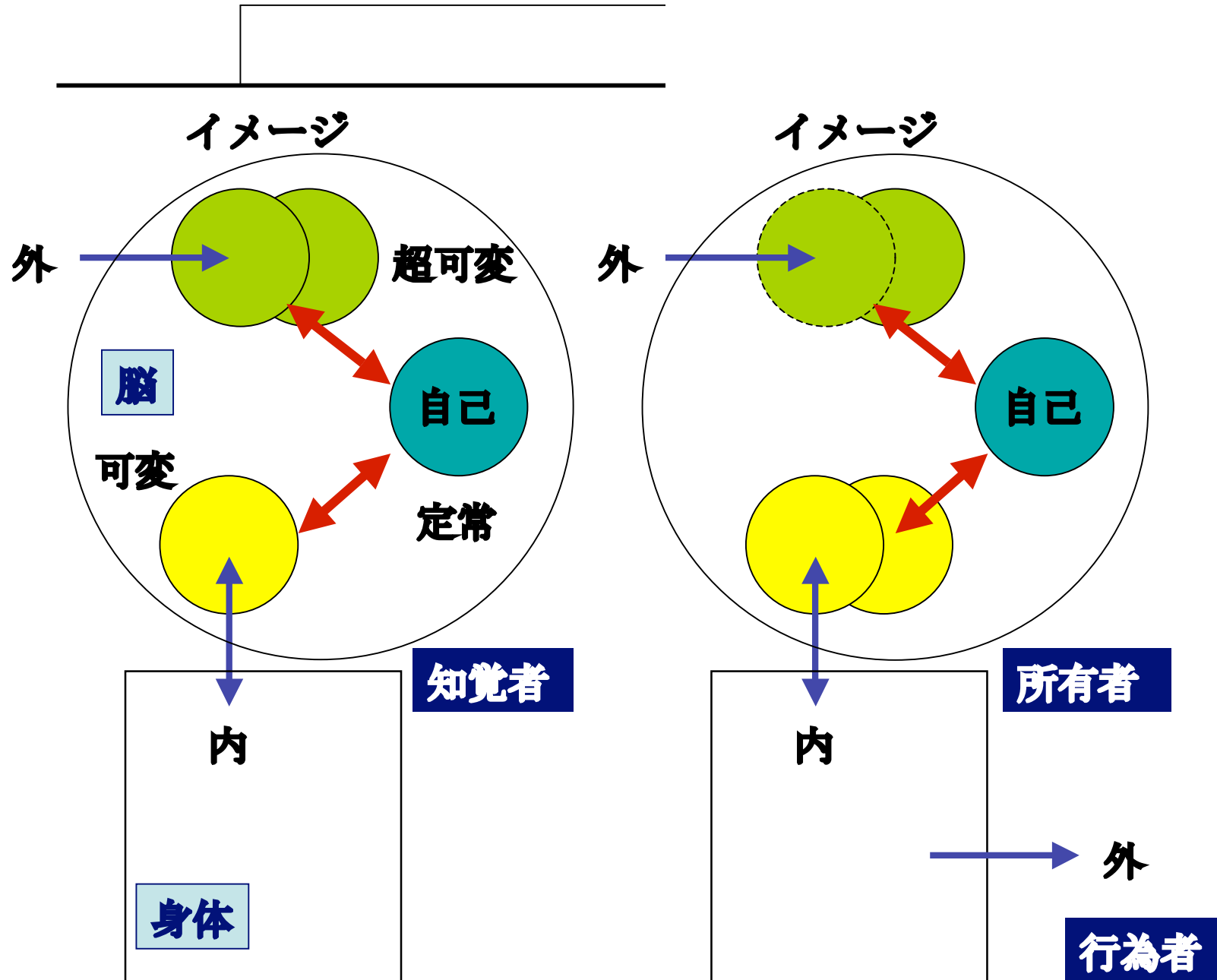


Endocytosis

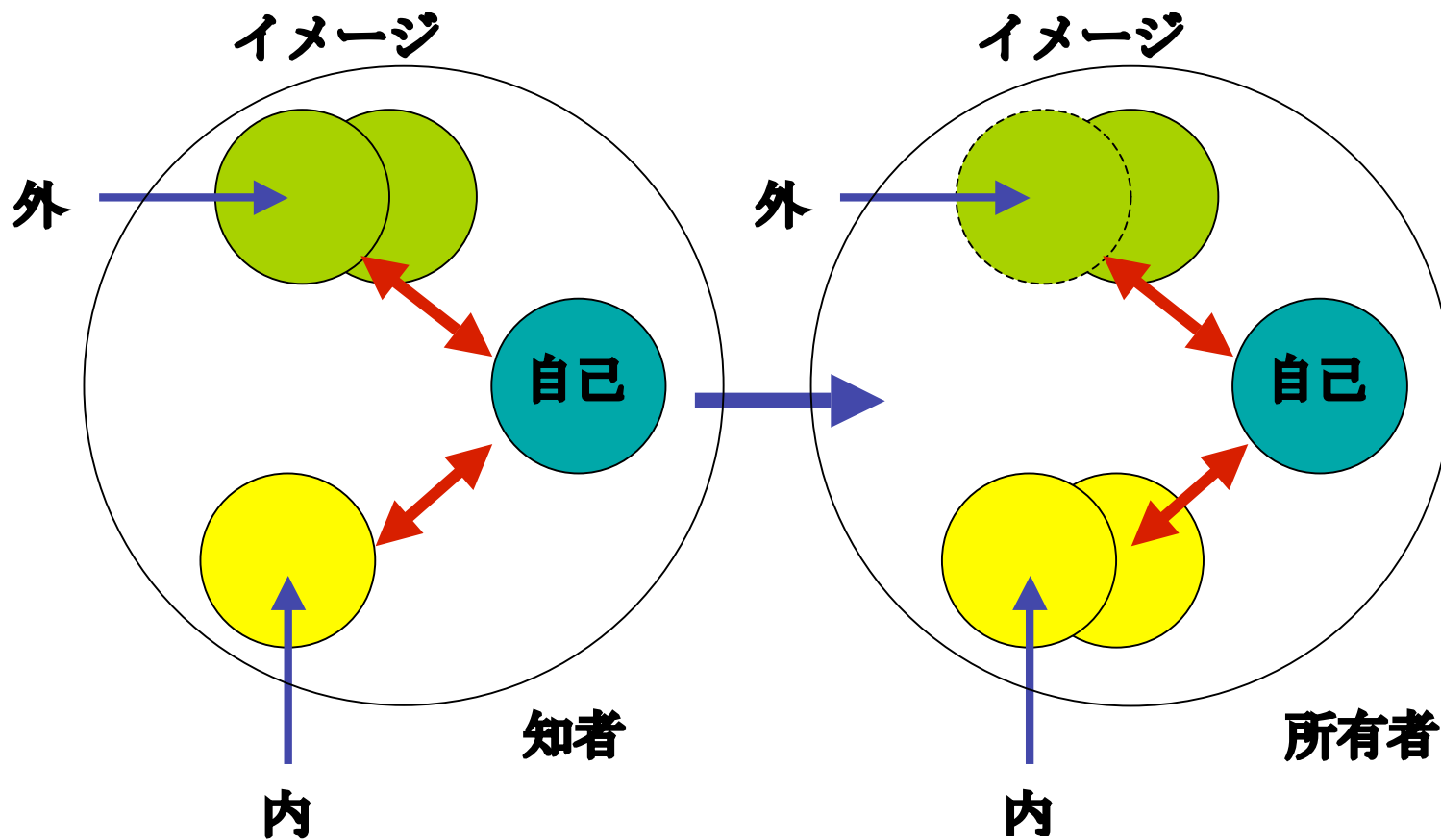
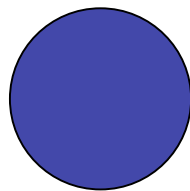
Exocytosis



対象性と主観性（自己性）の共通起源 —対象の認識から認識の認識へ—



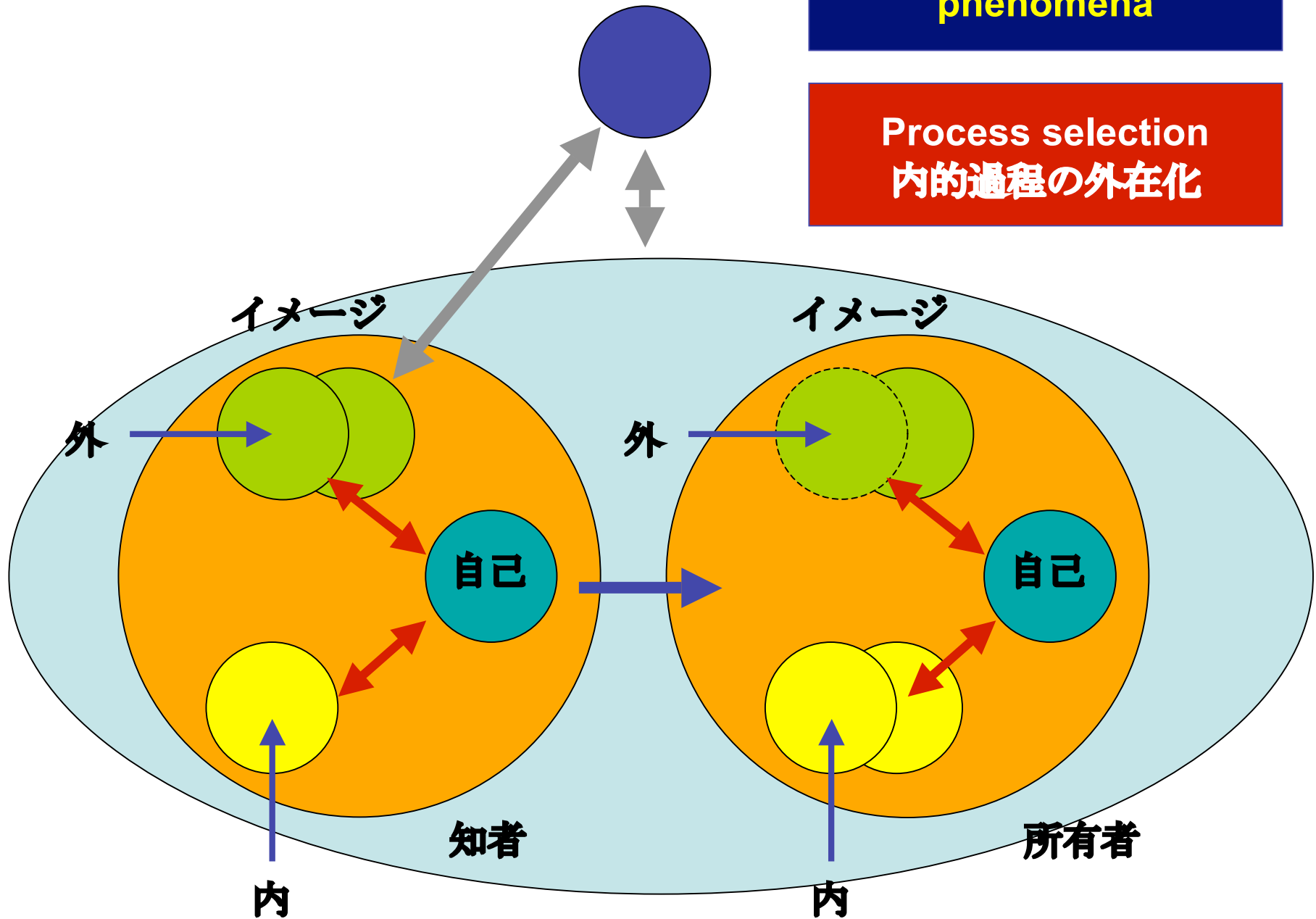
メタ自己



メタ自己

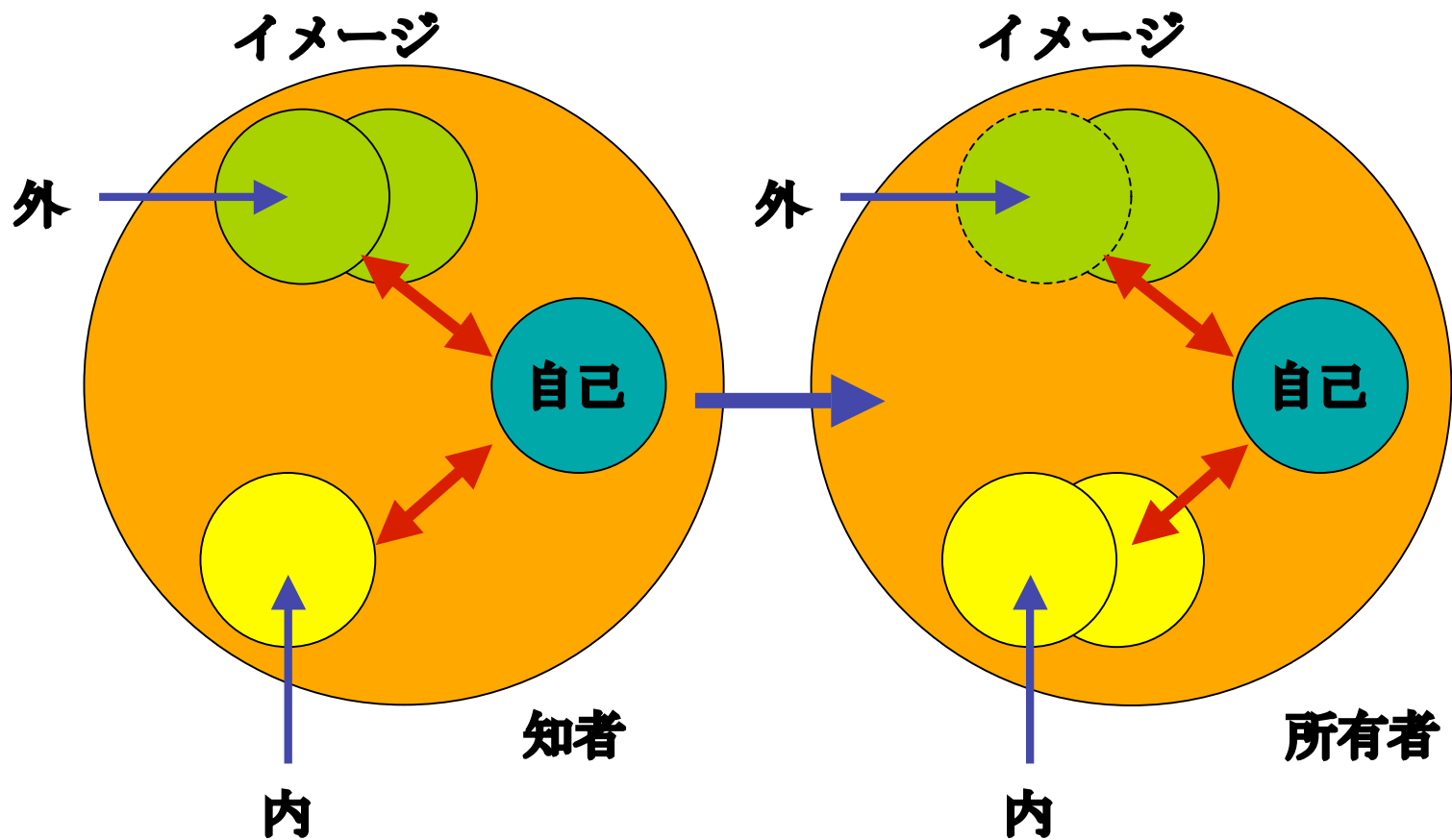
Meta-self as emergent phenomena

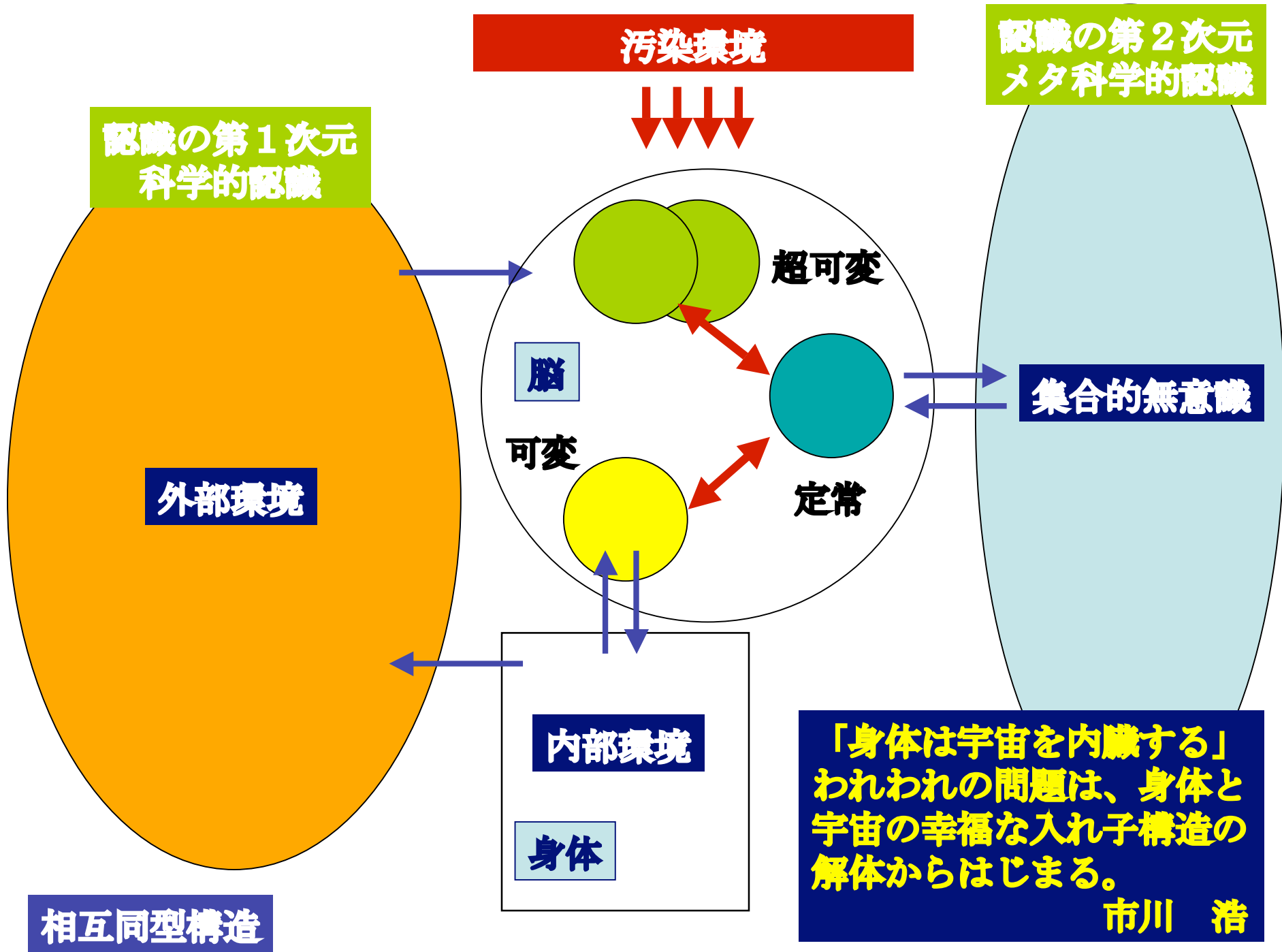
Process selection
内的過程の外在化



創造の内に破壊がある

Process selection
内的過程の外在化





汚染環境

認識の第2次元
メタ科学的認識

認識の第1次元
科学的認識

超可変

脳

可変

定常

集合的無意識

外部環境

内部環境

身体

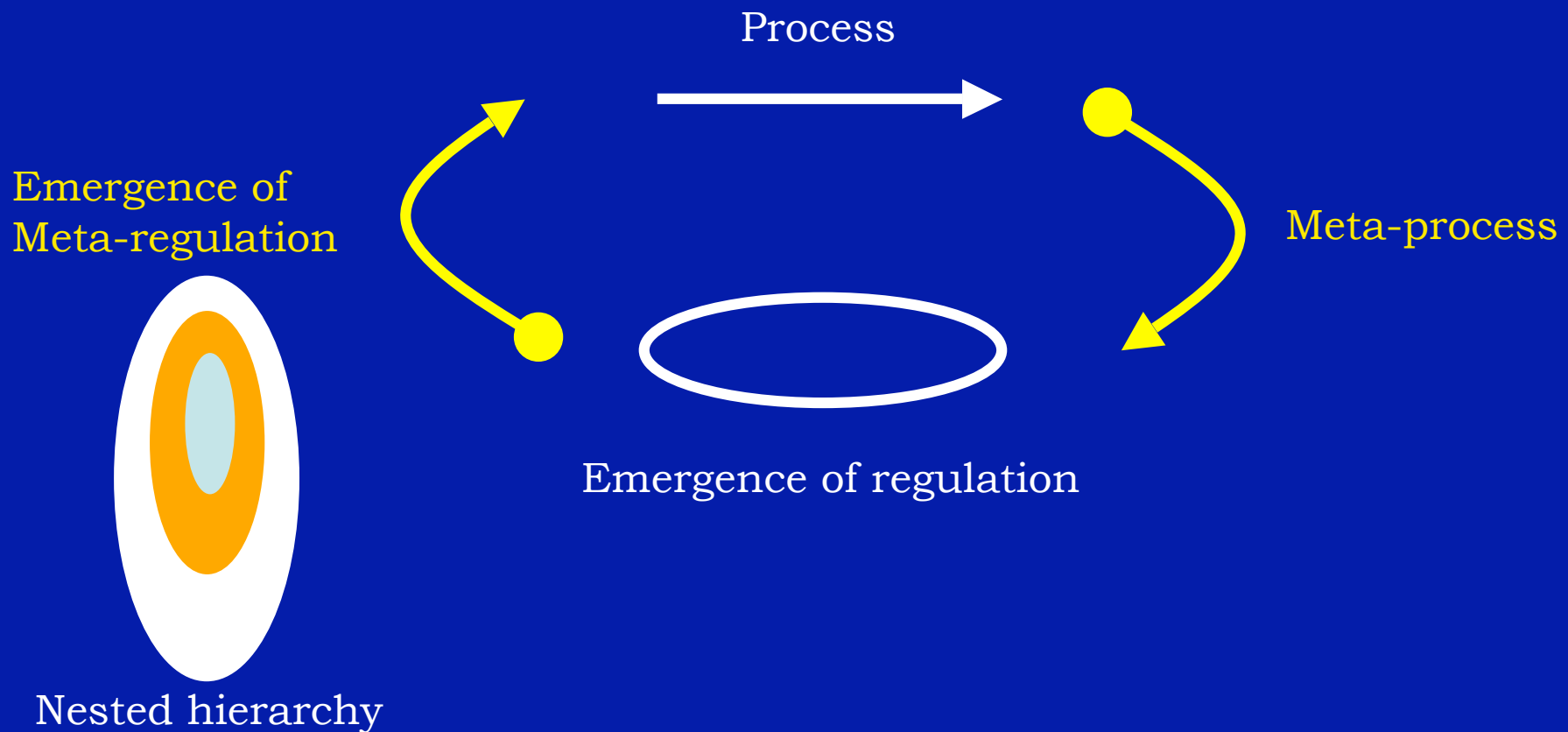
「身体は宇宙を内臓する」
われわれの問題は、身体と
宇宙の幸福な入れ子構造の
解体からはじまる。

市川 浩

相互同型構造

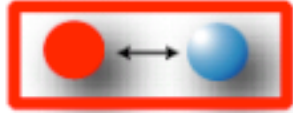
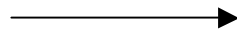
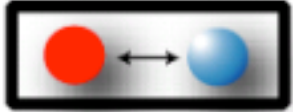
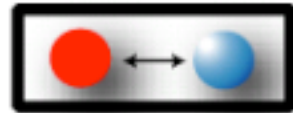
Emergence

- Object, subject, self, non-self, recognition, development, adaptation, evolution, health and disease as emergent phenomena



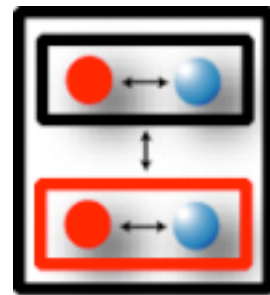
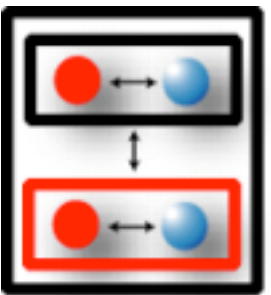
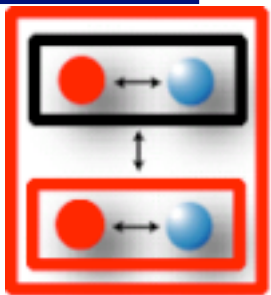
生命

認識



統一の多様性

多様性の統一



生成

進化

病気

全体性の認識とは

歴史上のあらゆる定説と反定説からなる対立を、現代の文脈において再構成すること。

→ マンダラの構成

社会・文化環境が、人間の認知プロセスに影響をおよぼすことが明らかになってきた。

(Nisbett, 2003)

→ 汚染環境による認知プロセスへの影響
理想環境での健常者と患者の研究の盲点

メタ生物学

客観科学

対象の認識

1980~2000年

「対象の認識」の認識



**認識の認識
2000年**

認知心理学

**「対象の認識」と
「認識の認識」の環境依存性**



**環境認識の環境依存性
2001年~**

環境認識病態学



創出 (Emergence)

- 異なる要素が共存することによって、各要素が独立に存在するときとは異なる状況が出現する。
 - 要素還元論への反省
- 同じ要素の組み合わせでも、履歴によって状況は変わる。主体、環境、およびそれらの相互作用における履歴過程をも要素として考慮する必要がある。
 - 過程還元論の必要性
- 思いがけない発展が生み出される反面、予期できない危機も創り出される。
 - 生と死の両義性

創造とは何か

創造の内に
破壊がある

「共通」

ポアンカレ

「連合」

ローレンツ

「同定」

湯川秀樹

「同一」

西田幾多郎

「同一」

市川 浩

「不定」

中村 元

「同着」

村瀬 学

「結合」

ユング

「共生」

マーグリス

「相補」

ボーア

「複製」

Nobody

生命とは何か

外の世界を閉め出す自己形成過程ではなく、
外の世界を内に取り込む自己・非自己循環過程である。
→ 精神の発達と病気の出現は同一起源をもつ。

<多様性の統一>

形式としては、普遍的な自己・非自己循環原理

<統一の多様性>

内容としては、自己否定を前提とした矛盾系の無限性

学問の創造

- 客観的な要素体系の複製ではなく、主観的な体験を伴う再構成が必要である。
 - 対象、問題、認識を自分で創り出す
失敗は必然
- 対象Aを理解するためには、Aでないものに一度視点を移行することによって、逆説的にAが理解できる。
 - 否定が肯定の前提
- 情報の喪失なしに、情報は得られない。
 - 矛盾のない体系の不完全性(ゲーデル)
矛盾のある体系による生命の理解