Major transitions 2.0 and human origins and evolution

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DIVERSE INTELLIGENCES

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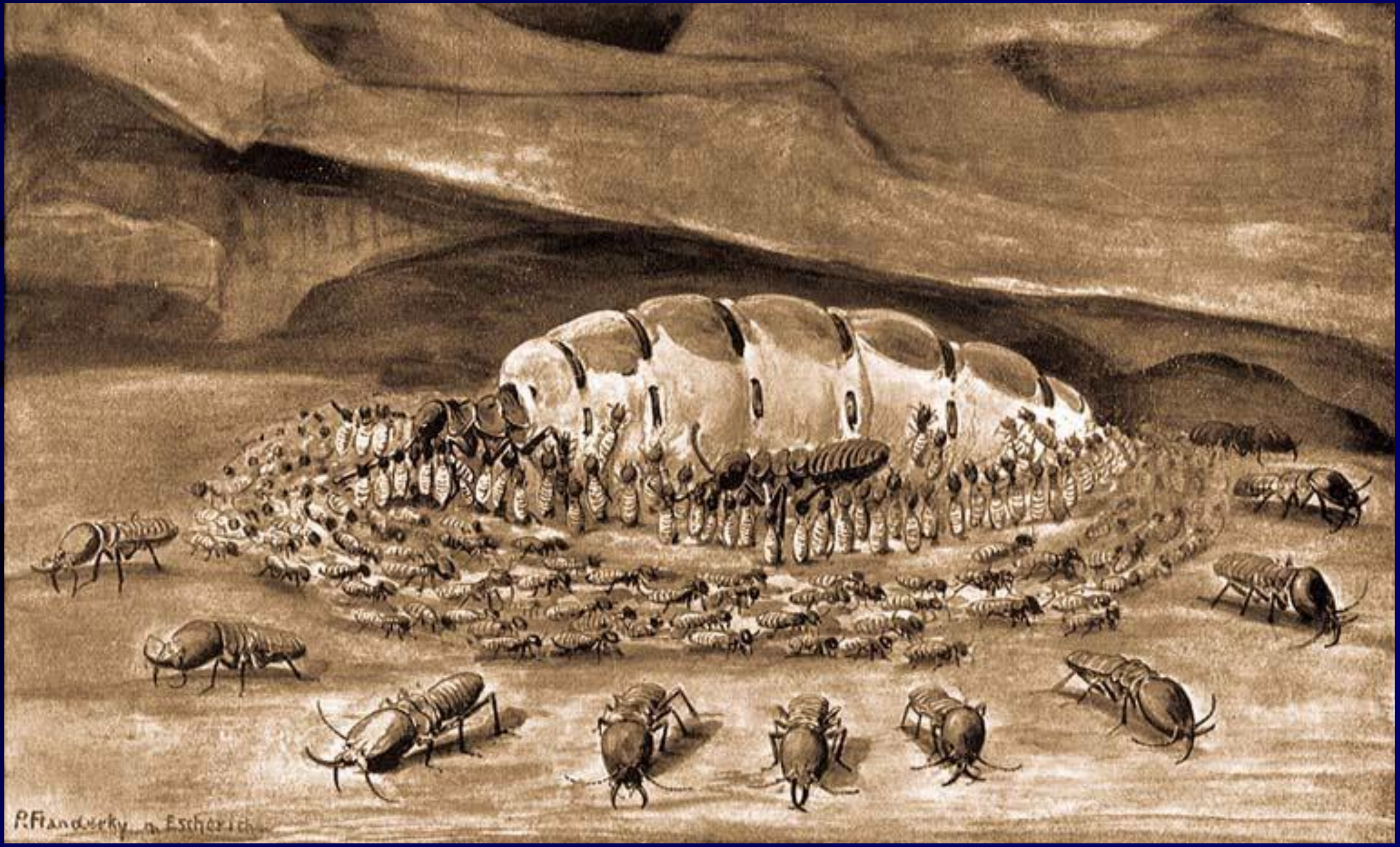
PARMENIDES FOUNDATION

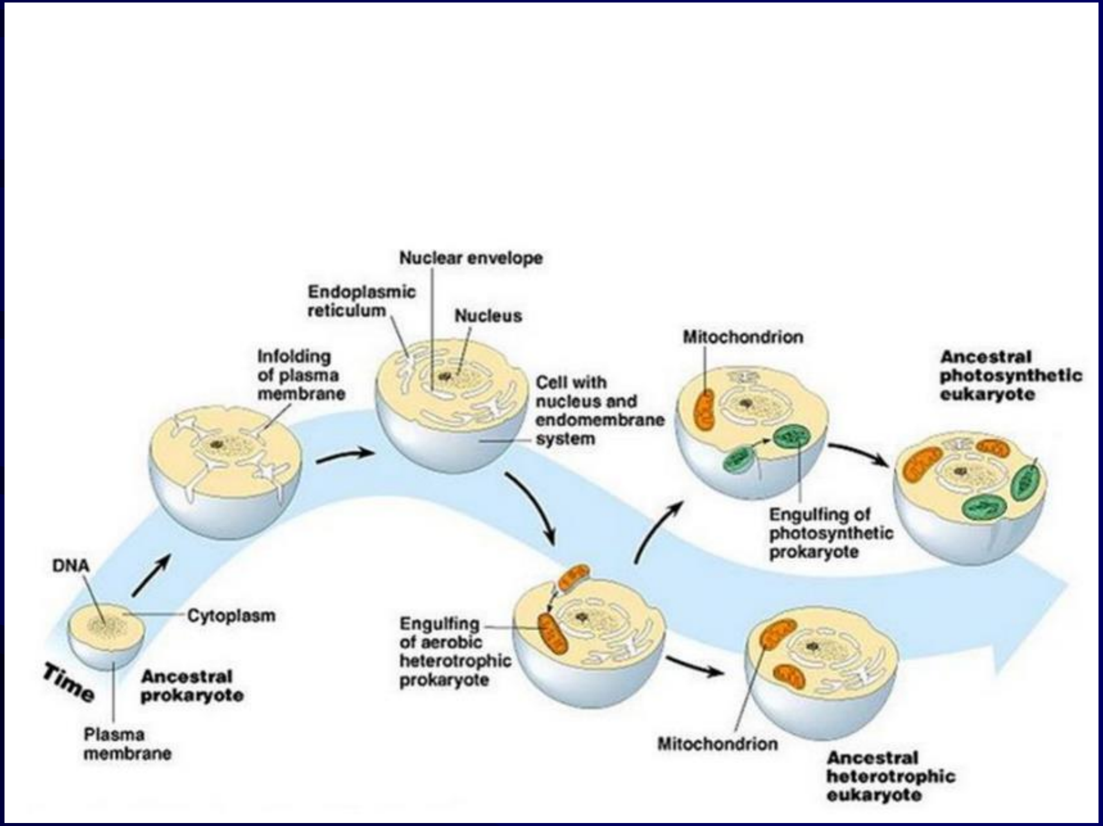
“Two books in one”

- Formation of higher-level units from lower ones (Major Transition in Individuality: MTI)
- Evolution of the storage, use and transmission of hereditary information

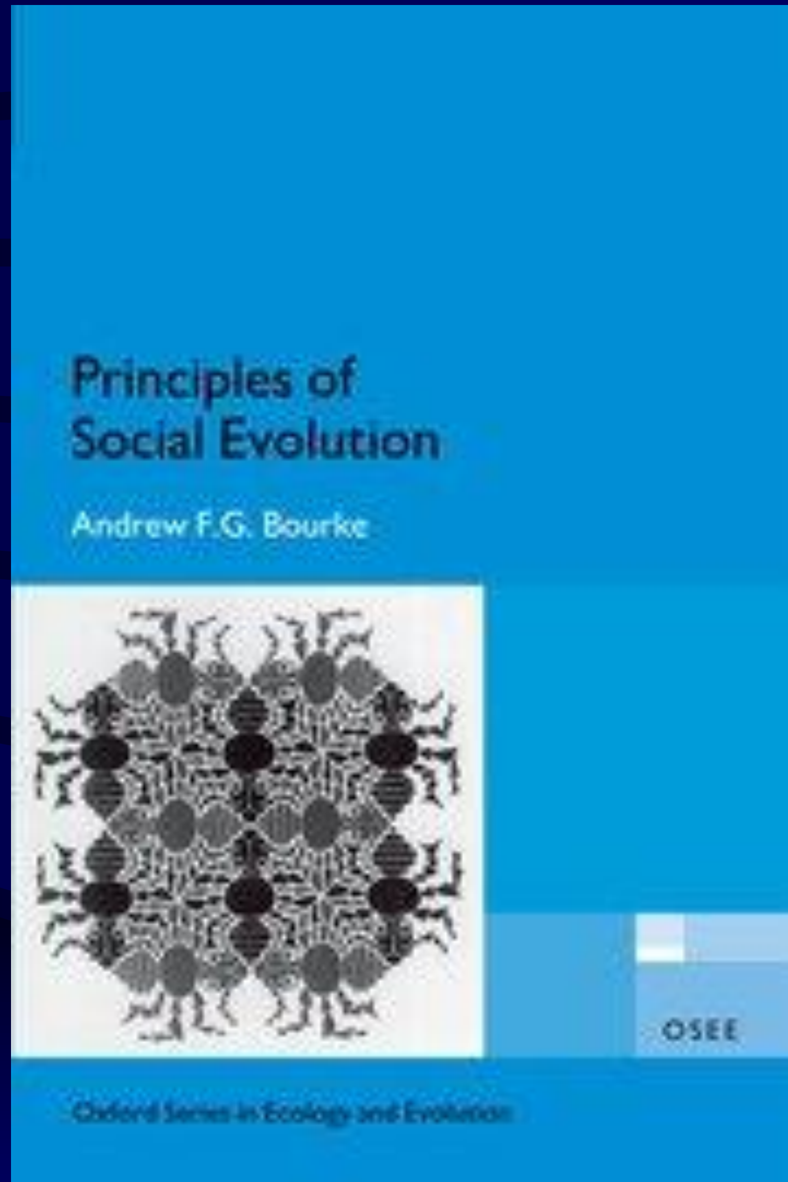
The royal chamber of a termite:fraternal



The origin of eukaryotic cells: egalitarian



No reproductive division of labour is possible!!!


Principles of
Social Evolution
Andrew F.G. Bourke
OSEE
Oxford Series in Ecology and Evolution

Three phases of a major transition (Bourke, 2011)

Major transition examples	**Social group formation**	**Social group maintenance**	**Social group transformation**
Eukaryote origins	Origin of the eukaryotic cell	Control of organellar reproduction	Gene transfer from organelle to nucleus
Clonal organisms to sexual unicells	Origin of zygotes	Control of meiotic drive	Obligate sexual reproduction
Unicells to multicellular organisms	Origin of multicellularity	Control of selfish cell lineages	Early-diverging germline

- These can easily span many million years!

Toward major evolutionary transitions theory 2.0

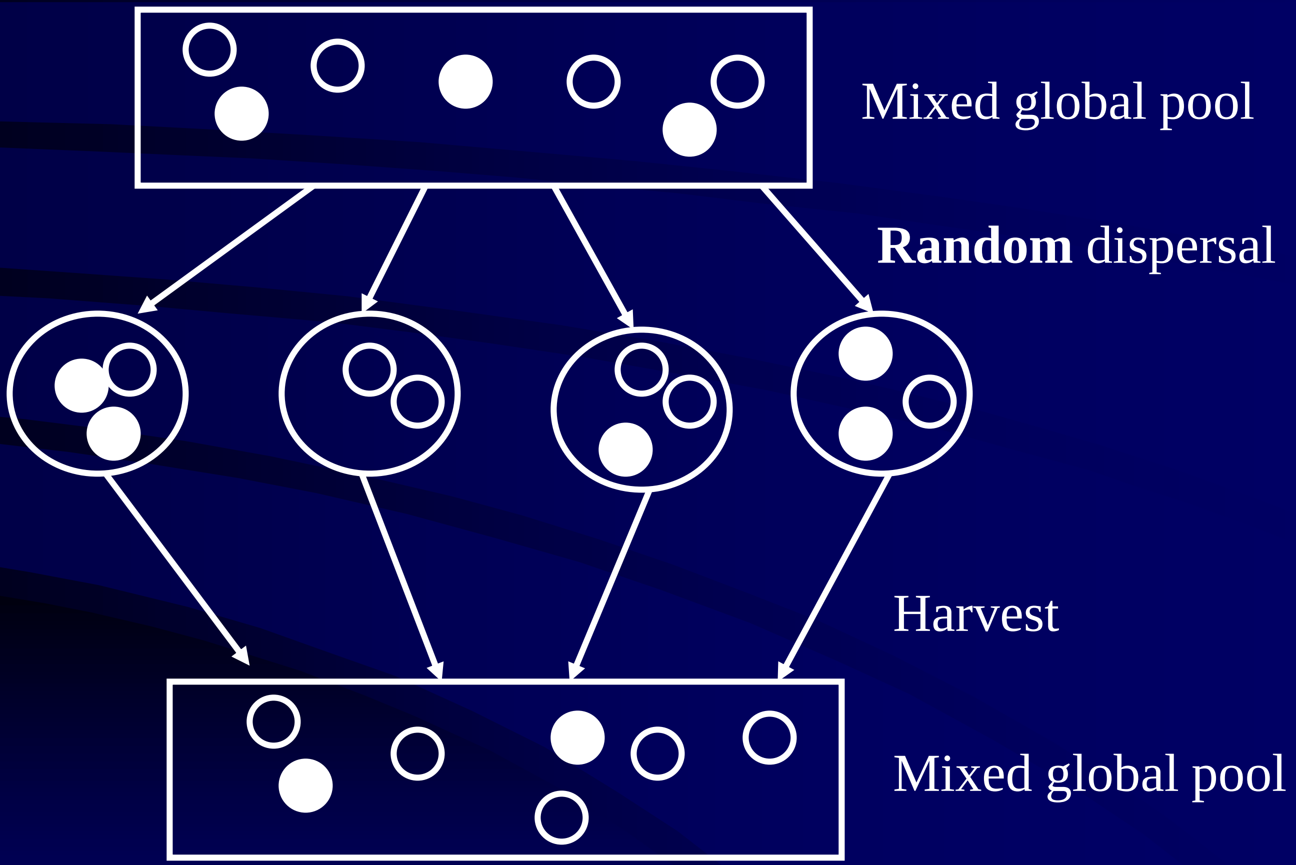
Eörs Szathmáry[1]

COLLOQUIUM PAPER

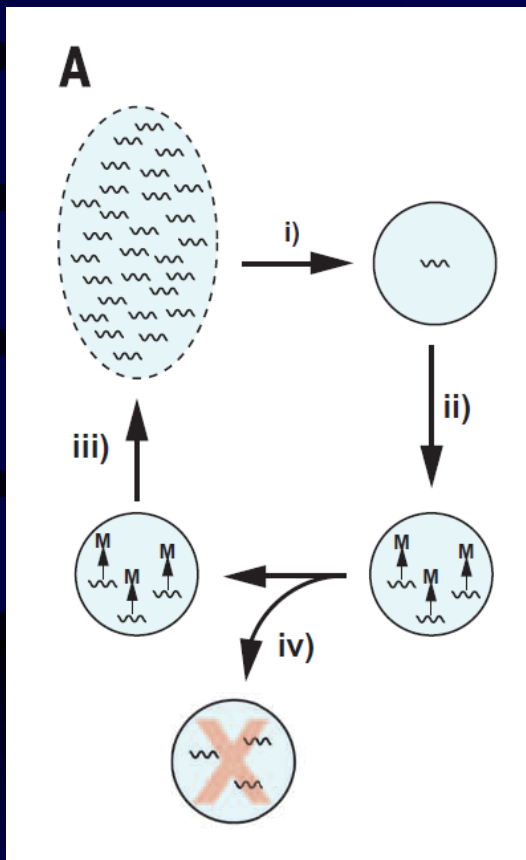
Table 1. Revised major transitions

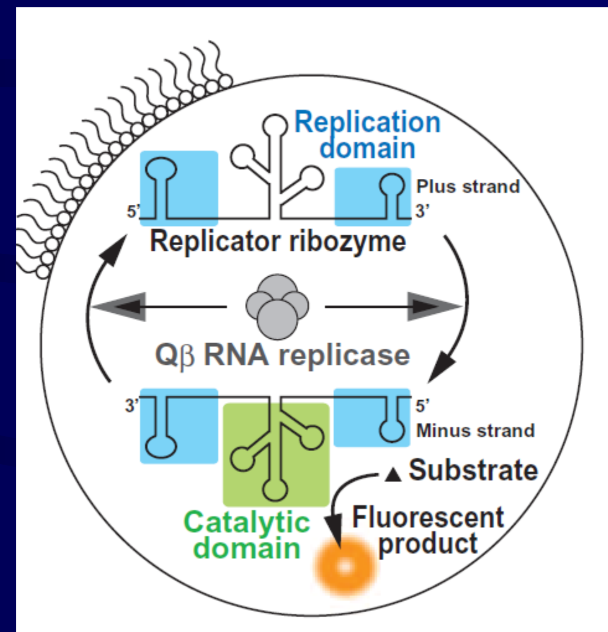
Origin of:	Formation, maintenance, transformation phases	Transition in individuality	New type of information storage, use, and transmission	Limited transitions
Protocells	1. Autocatalytic networks on the rocks cooperate 2. Naked genes escape into compartments 3. Chromosomes form	MLS1 on the rocks MLS2 in compartments Chromosomes as conflict mediators	Catalysts based on informational replication arise Genetic information encapsulated in cells	
Genetic code and translation: prokaryotic cells	1. Limited coding before translation (coenzyme amino acids and peptides) 2. Early ribosomes and primitive translation 3. Vocabulary extension by bacterial sex	Establishment of symbiotic autocatalytic molecular networks, including complementary subcodes	Symbolic as opposed to earlier iconic hereditary system (code) Coded sexuality	21st and 22nd amino acids (selenocystein and pyrrolisine) Highly polyploid bacteria
Eukaryotic cells	1. Fusion–fission cycle (early sex) 2. Mitochondrial symbiont (before or after phagocytosis) 3. Nucleus, meiosis, and mitosis	Different cells come and stay together as a higher level whole	Genome composed of functionally synergistic compartments Separation of transcription from translation	Within-cell soma and germ (ciliates)
Plastids	1. Engulfment of plastids 2. Transfer of plastid genes to nucleus 3. Posttranslational import and regulation of division	Different cells come and stay together as a higher level whole	Genome composed of functionally synergistic compartments	Tertiary plastids *Paulinella*
Multicellularity (plants, animals, fungi)	1. Size advantage from cohesion 2. Programmed regulation of cell division 3. Soma and early-sequestered germ line	Cohesive multicellularity allows for differentiation and division of labor	Epigenetic inheritance systems with high hereditary potential	Multicellularity in other lineages Multi-multi symbioses (e.g., lichens)
Eusocial animal societies	1. Origin of societies 2. Control of conflict (dominance, punishment, policing) 3. Dimorphic reproductive and nonreproductive castes	Formation of (super)organisms	Animal signaling and social learning	Unicolonial ant supercolonies
Societies with natural language	1. Confrontational scavenging, first words 2. Eusociality (grandmothers) and protolanguage 3. Cultural group selection and syntax	Non-kin, large-sized cooperation based on negotiated division of labor Food sharing and reproductive leveling Cultural groups	Symbolic communication with complex syntax	Animal cultures

The trait group model (Wilson, 1975)



A molecular rendering of the Wilson model





ORIGIN OF LIFE

Transient compartmentalization of RNA replicators prevents extinction due to parasites

SCIENCE sciencemag.org 9 DECEMBER 2016 • VOL 354 ISSUE 6317 1293

The sums for MCRM

$$\frac{dx}{dt} = axxy - xF$$

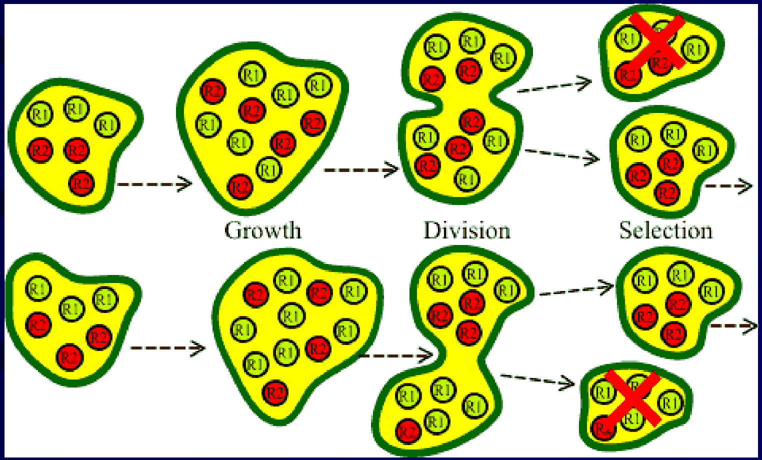
$$\frac{dy}{dt} = byxy - yF$$

Metabolism

Hamilton does not rule

Binomial coefficient	1	2	1
Production of X	0	*a*	0
Production of Y	0	*b*	0

Stochastic corrector model (SCM)



- Independently reassorting genes
- Selection for optimal gene composition between compartments
- Competition among genes within the same compartment
- Stochasticity in replication and fission generates variation on which natural selection acts
- A stationary compartment population emerges

Filial transitions: „darwinisation”

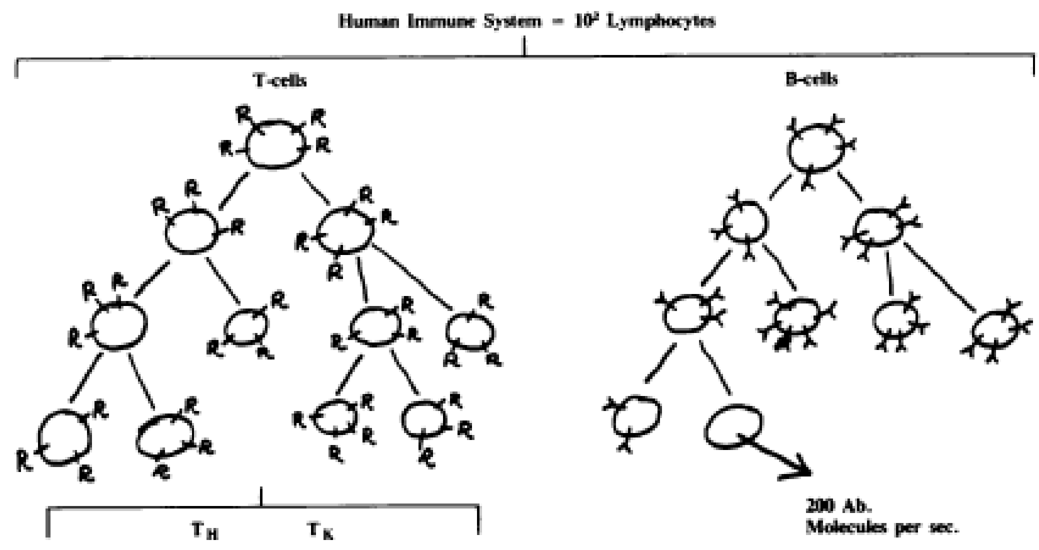
- Classical transitions: emergence of new levels of evolution by terminal addition
- De-darwinisation of the lower level
- Filial transitions: emergence of new (constrained) evolutionary system by „intercalation“
- „Darwinising“ some components of the existing unit!

When the Darwinian dynamic reinvented itself

The EMBO Journal vol.4 no.4 pp.847–852, 1985

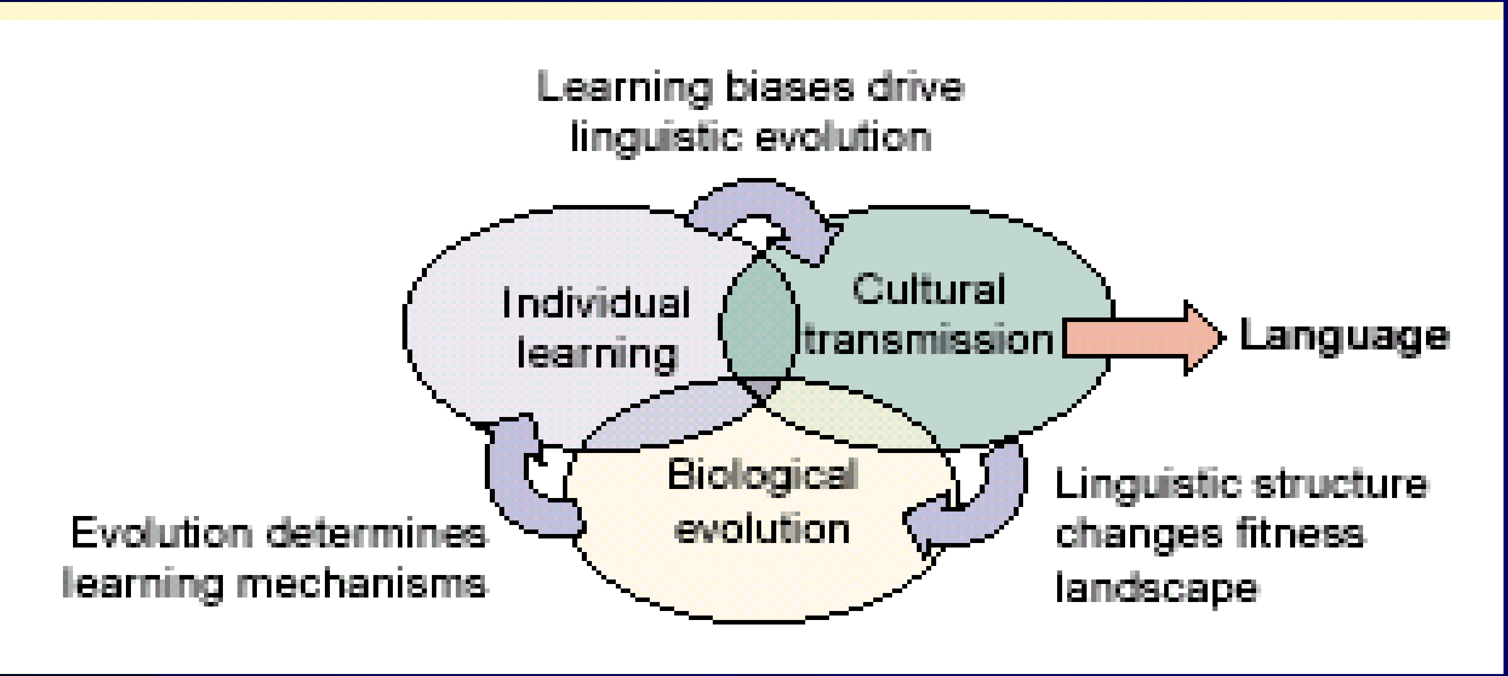
The generative grammar of the immune system

Niels K.Jerne M.D. FRS.



More like
artificial selection!

What makes us human?



- Note the different time-scales involved
- Cultural transmission: language transmits itself as well as other things
- A novel inheritance system

Confrontational scavenging

Bickerton and Szathmáry *BMC Evolutionary Biology* 2011, **11**:261
http://www.biomedcentral.com/1471-2148/11/261

BMC Evolutionary Biology

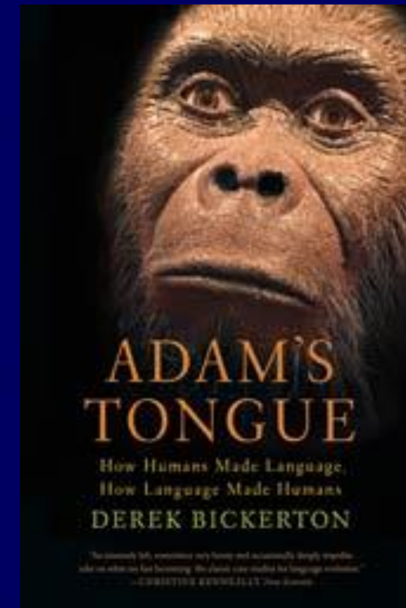
COMMENTARY **Open Access**

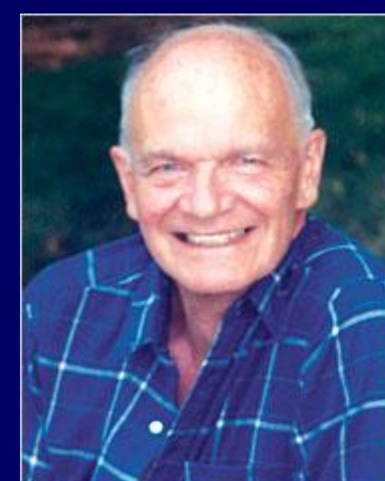
Confrontational scavenging as a possible source for language and cooperation

Derek Bickerton[1] and Eörs Szathmáry[2,3,4*]

Abstract

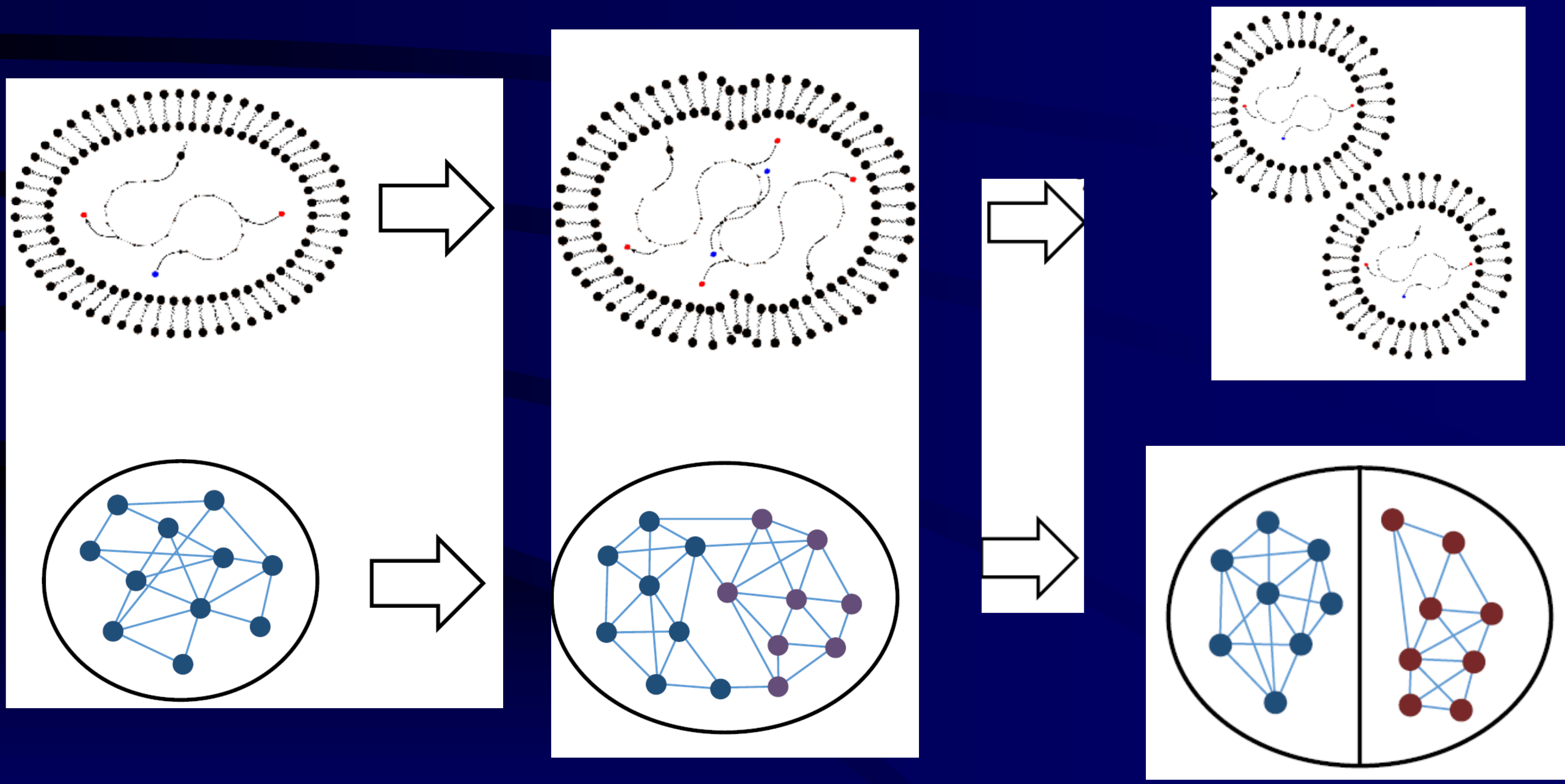
The emergence of language and the high degree of cooperation found among humans seems to require more than a straightforward enhancement of primate traits. Some triggering episode unique to human ancestors was likely necessary. Here it is argued that confrontational scavenging was such an episode. Arguments for and against an established confrontational scavenging niche are discussed, as well as the probable effects of such a niche on language and co-operation. Finally, several possible directions for future research are suggested.





Toward a Macroevolutionary Theory of Human Evolution: The Social Protocell

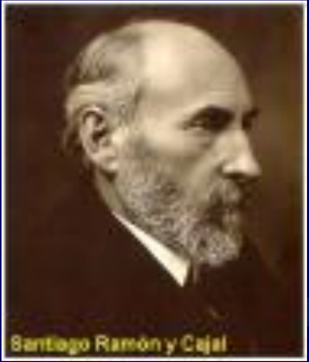
Claes Andersson[1] · Petter Törnberg[1]



The sociont

- A cultural entity *contained* in the community
- Different, often specific cultural items that are not interchangeable
- Cultural content affects *group fitness*
- EGALITARIAN transition
- Selection for linked “meme complexes” (cf. chromosome formation)
- Teaching and schooling

Recuerdos de mi vida (Cajal, 1917, pp. 345–350)



"At that time, the generally accepted idea that the differences between the brain of [non-human] *mammals (cat, dog, monkey, etc.) and that of man are only quantitative, seemed to me unlikely and even a little offensive to human dignity. . .*

but do not articulate language, the capability of abstraction, the ability to create concepts, and, finally, the art of inventing ingenious instruments. . .

seem to indicate (even admitting fundamental structural correspondences with the animals) the existence of original resources, of ***something qualitatively new*** *which justifies the psychological nobility of Homo sapiens?. . . ".*

Candidate mechanisms of "neuronal replication"

- Local connectivity copying
- Copying of activity patterns in bistable neurons
- Path evolution
- Other?

Chrisantha Fernando

Bayes and selection (e.g. Harper, 2010)

$$P(H_i \mid E) = \frac{P(E \mid H_i)P(H_i)}{P(E)}$$

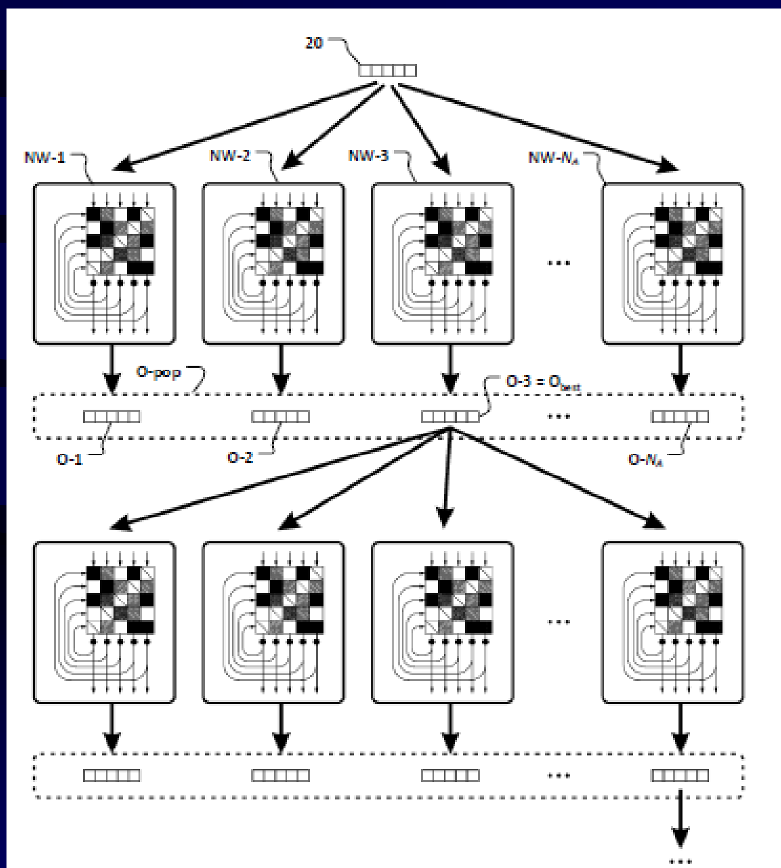
$$x'_i = \frac{x_i f_i(\mathbf{x})}{f(\mathbf{x})},$$

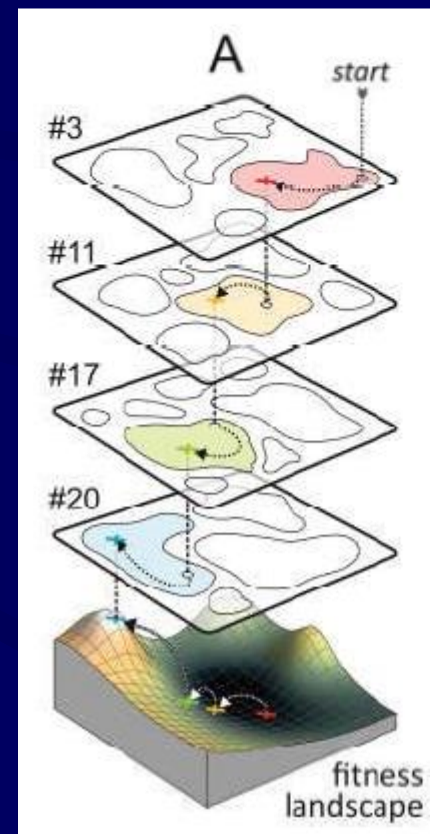
Bayesian Inference	Discrete Replicator
Prior Distribution $(P(H_1), \ldots, P(H_n))$	Population state $x = (x_1, \ldots, x_n)$
New Evidence $P(E \mid H_i)$	Fitness landscape $f_i(x)$
Normalization $P(E)$	Mean fitness $\bar{f}(x)$
Posterior distribution $P(H_1 \mid E), \ldots, P(H_n \mid E)$	Population state $x' = (x'_1, \ldots, x'_n)$

RESEARCH ARTICLE

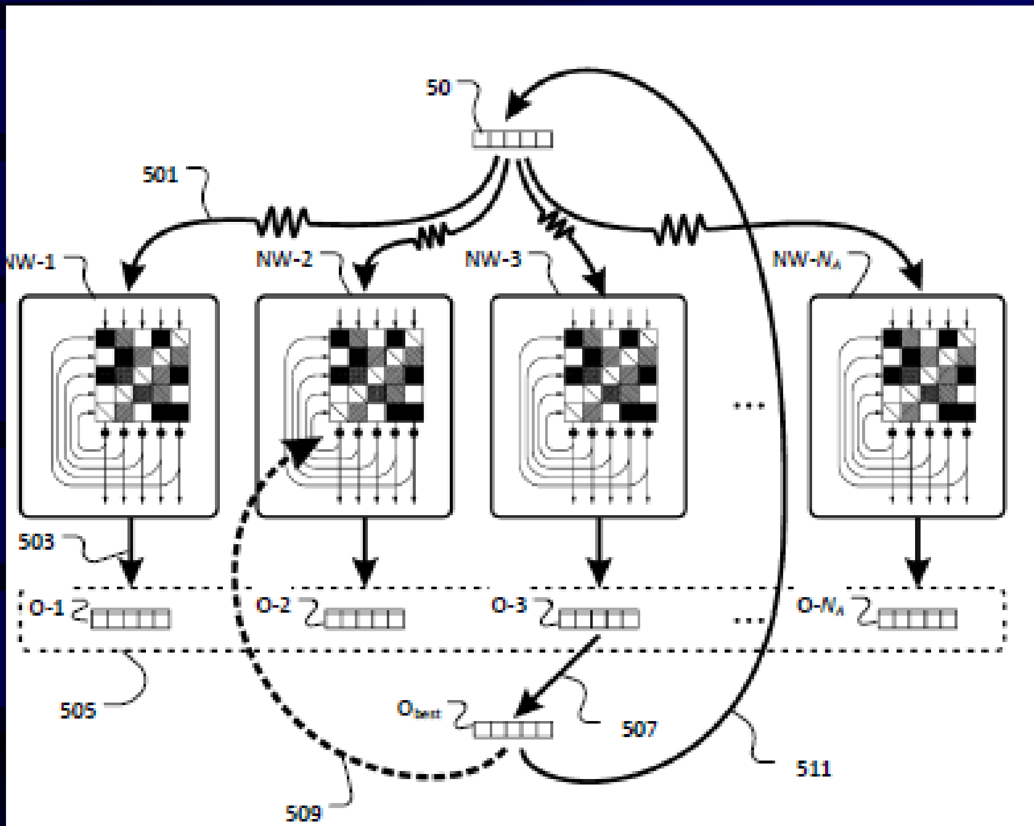
REVISED **Breeding novel solutions in the brain: A model of Darwinian neurodynamics [version 2; referees: 3 approved]**

András Szilágyi[1-3*], István Zachar[1,3,4*], Anna Fedor[1-3], Harold P. de Vladar[1,3], Eörs Szathmáry[1-5]

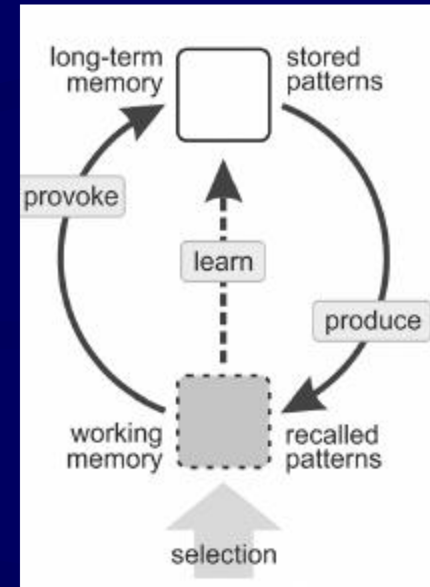


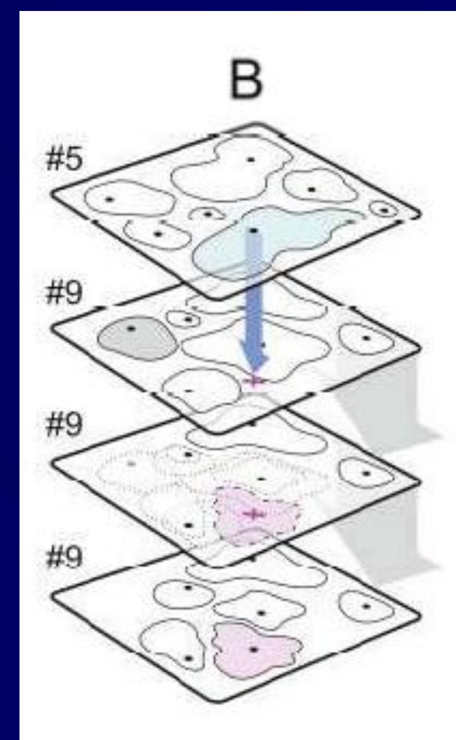


Evolution



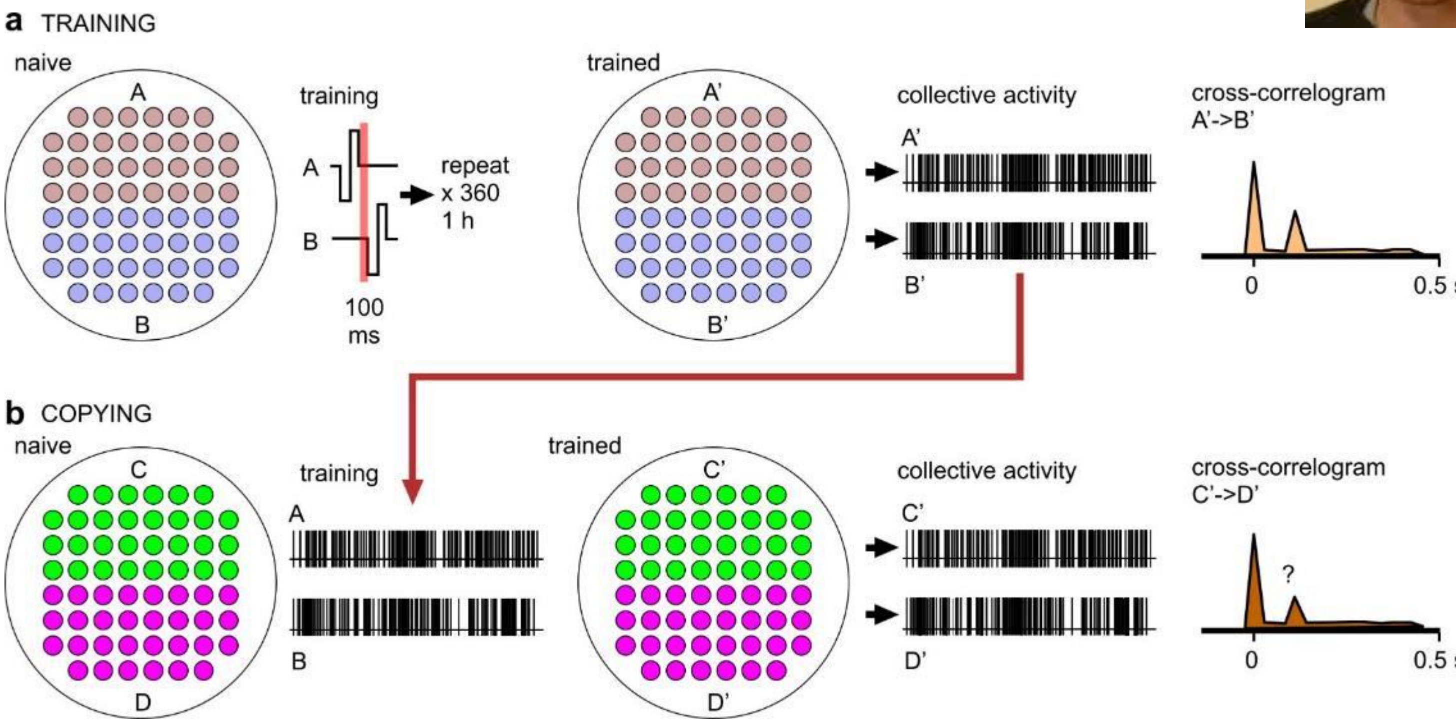
- Crucial is the COPYING of patterns from one network to the other!!!
- To be able to do so requires past genetic evolution





INSIGHT

39th Month Meeting | Riva del Garda, ITALY |



Thanks for your attention!