

100 YEARS

host

host-microbe

macro-micro-.....

Lessons from Internalism vs. Externalism Debates in Biology and Psychology



erc

Lynn Chiu, Immuno ConcEpT Lab
University of Bordeaux/CNRS 5/4/2016

Outline

Hypes in Microbiome research

Three Lessons from Internalist vs. Externalist Debates



External Control

Can Microbes Control Criminal Behavior?

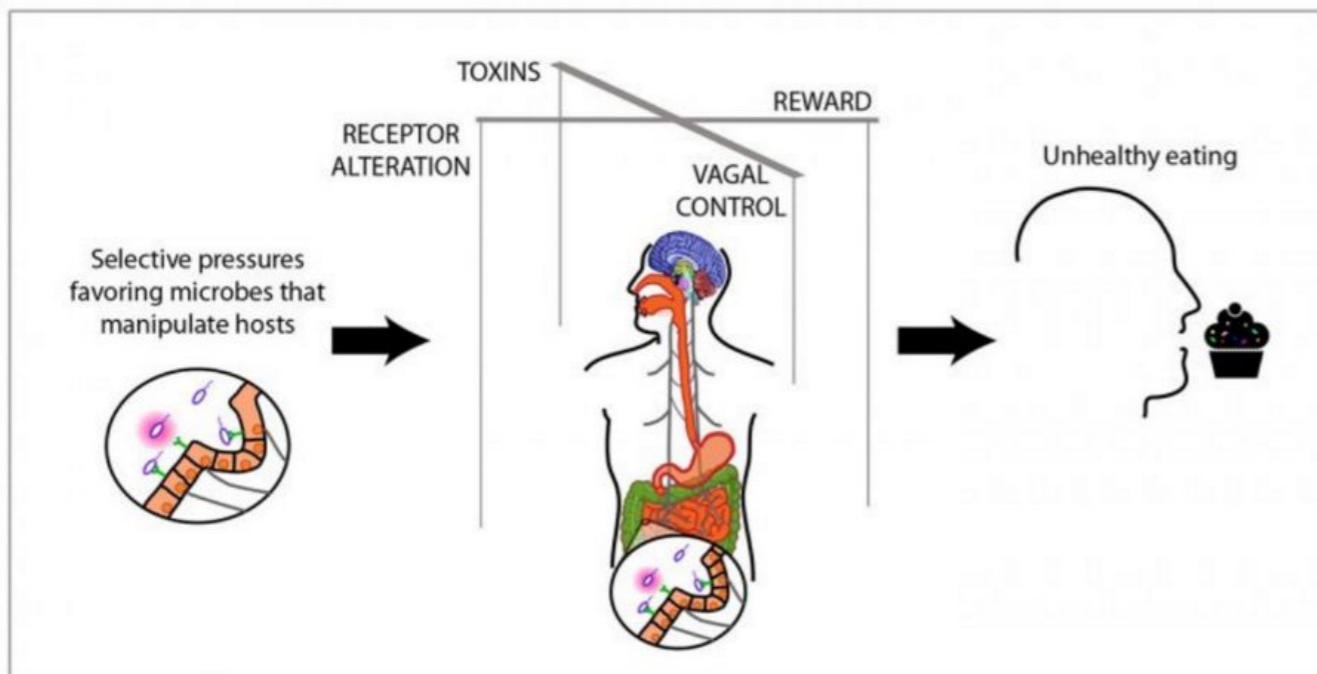
May 25, 2015 | 310 views | 15 Likes | 4 Comments | [in](#) [f](#) [t](#)



SCIENCE/TECH

Gut Bacteria Control Our Minds To Get The Food They Want; How Countering This Can Fight Obesity

Aug 17, 2014 12:43 PM By Anthony Rivas



Our bodies contain trillions of bacteria, all of which control our minds in order to get the foods they want. Controlling them back may help fight obesity.

Photo courtesy of Shutterstock

Are we at the mercy of our gut bacteria? The above image illustrates how microbes can "pull our strings," driving us to crave foods that give them the nutrients they need, including fat and sugar.

↑ 2 Vote(s) | 0 Comments

It is therefore tempting to speculate that symbiotic bacteria direct innate immune responses of the gut in an effort to protect their environment.

Perhaps the mammalian immune system which appears designed to control microbes is, in fact, controlled by the microbes themselves.

Although significant work is still required to determine the beneficial immune responses induced by the microbiota, it is exciting to consider the teleological notion that indigenous bacteria actively prevent enteric disease by infectious microorganisms to fortify their niche.

The gut microbiota shapes intestinal immune responses during health

an **Cell Host & Microbe**

June | **Review**

Abstra

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Control of Brain Development, Function, and Behavior by the Microbiome

Timothy R. Sampson¹ and Sarkis K. Mazmanian^{1,*}

¹Division of Biology & Biological Engineering, California Institute of Technology, Pasadena, CA 91125, USA

*Correspondence: sarkis@caltech.edu

<http://dx.doi.org/10.1016/j.chom.2015.04.011>



Contents lists available at ScienceDirect

Zoology

journal homepage: www.elsevier.de/zool

ZOOLOGY

Review

Metaorganisms as the new frontier

Thomas C.G. Bosch^{a,*}, Margaret J. McFall-Ngai^b

^a Zoological Institute, Christian-Albrechts-University Kiel, Am Botanischen Garten 1-9, D-24118 Kiel, Germany

^b Department of Medical Microbiology and Immunology, University of Wisconsin-Madison, 1550 Linden Drive, Madison, WI 53706, USA

Bacteria also must be seen as an essential part of the vertebrate immune system. The paradigm that the adaptive immune system has evolved to control microbes has been modified to include the concept that the immune system is in fact controlled by microorganisms (McFall-Ngai, 2007; Eberl, 2010).

**Unit of Biological Organization:
Holobiont/Superorganism/Metaorganism**

THE BLOG

Congrats: You Are Officially a Superorganism

🕒 04/10/2015 01:53 pm ET | Updated Jun 10, 2015

376



Like 4.1K



Max Lugavere

Director of upcoming documentary "Bread Head", TV personality.



One of the most interesting fields of study today is the gut-brain axis, a burgeoning topic with vast implications that we are now, for the first time, starting to appreciate. The gut, or gastrointestinal tract — the long tube that starts at your mouth and ends

HUFF POST

The pronoun 'I' is becoming obsolete

by David Salisbury | Aug. 19, 2015, 9:36 AM | [Want more research news? Subscribe to our weekly newsletter »](#)

SHARELINES

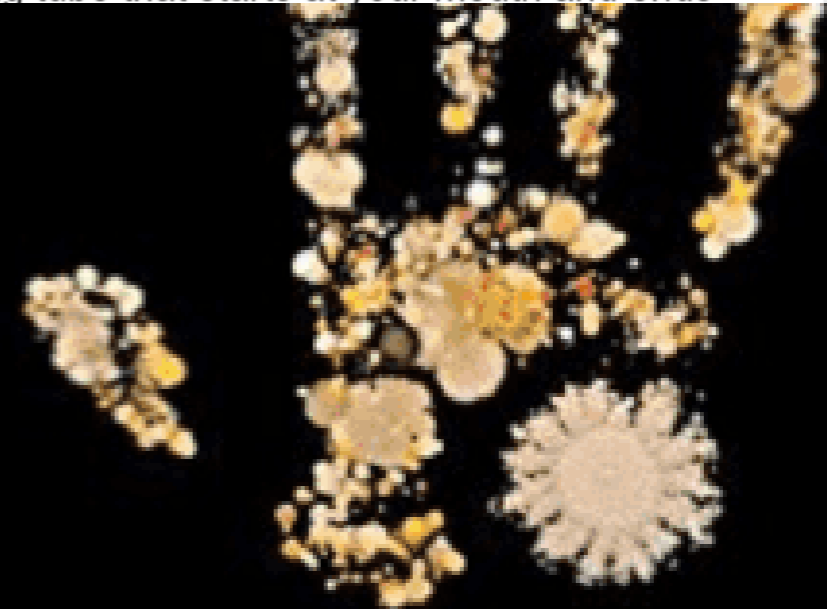
Me and my microbes: why no one is ever truly alone



Tree of life created with bacterial cultures. (Robert Brucker / Harvard University)

Microbiome results argue for new view of animals as superorganisms

BY TINA HESMAN SAEY 2:00PM, DECEMBER 20, 2013



RODNEY DIETERT, PhD

Holobiont

coral communities

unit of selection

2007

Review

Nature Reviews Microbiology **5**, 355–362 (1 May 2007) | doi:10.1038/nrn

The role of microorganisms in coral health, disease and evolution

Eugene Rosenberg , Omry Koren , Leah Reshef , Rotem Efrony & Ilana Zilber-Rosenberg

2009

Review

Microbial disease and the coral holobiont

David G. Bourne¹, Melissa Garren², Thierry M. Work³, Eugene Rosenberg⁴, Garriet W. Smith⁵ and C. Drew Harvell⁶

2008

REVIEW ARTICLE

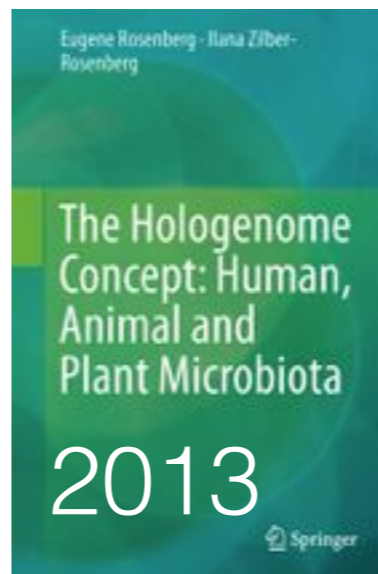
“fundamental biological organization”



Role of microorganisms in the evolution of animals and plants: the hologenome theory of evolution

Ilana Zilber-Rosenberg¹ & Eugene Rosenberg²

¹Teaching at the Open University of Israel, Raanana, Israel; and ²Department of Molecular Microbiology and Biotechnology, Tel Aviv University, Ramat Aviv, Israel



2015

ESSAY

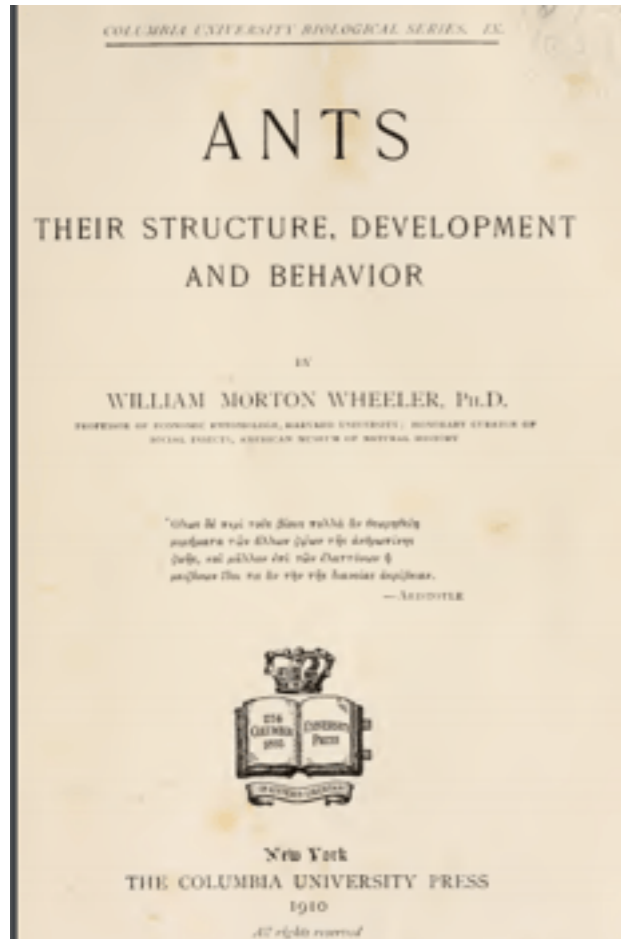
Host Biology in Light of the Microbiome: Ten Principles of Holobionts and Hologenomes

Seth R. Bordenstein^{1,2*}, Kevin R. Theis³

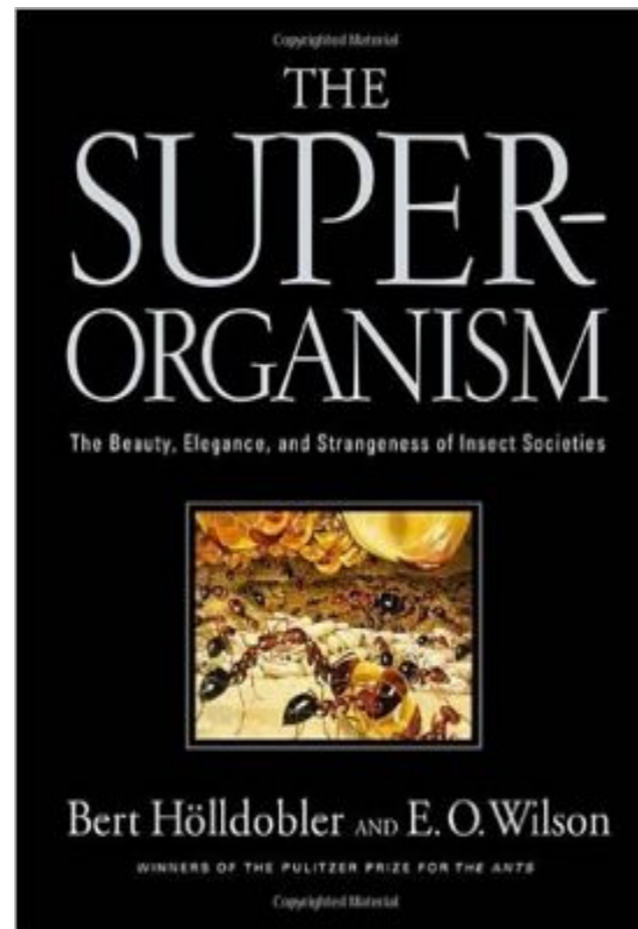
¹ Department of Biological Sciences, Vanderbilt University, Nashville, Tennessee, United States of America, ² Department of Pathology, Microbiology, and Immunology, Vanderbilt University, Nashville, Tennessee, United States of America, ³ Department of Internal Medicine, University of Michigan, Ann Arbor, Michigan, United States of America

* s.bordenstein@vanderbilt.edu

1910



2009



1989

Reviving the Superorganism

DAVID SLOAN WILSON AND ELLIOTT SOBER

Department of Biological Sciences, State University of New York, Binghamton, New York 13901, U.S.A. and Department of Philosophy, 5185 Helen C. White Hall, University of Wisconsin, Madison, Wisconsin 53706, U.S.A.

(Received 25 July 1988, and accepted in revised form 18 October 1988)

2013

**Colonies Are Individuals:
Revisiting the Superorganism Revival**

Matt Haber

social insect colonies
(single species, often monogenomic)

level of selection
(single species)

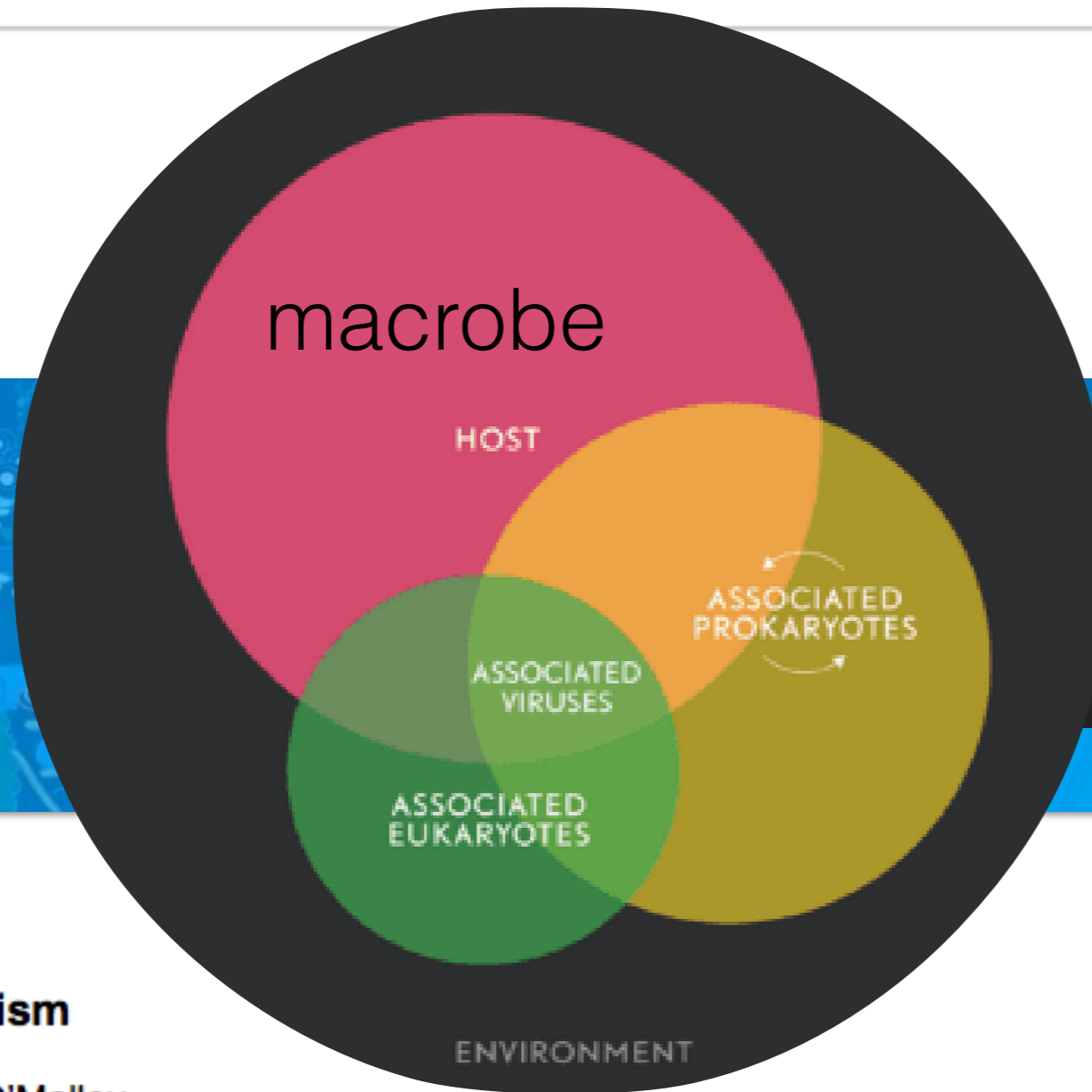
Superorganism

Metaorganisms as the new frontier 2011

Thomas C.G. Bosch^{a,*}, Margaret J. McFall-Ngai^b

^a Zoological Institute, Christian-Albrechts-University Kiel, Am Botanischen Garten 1-9, D-24118 Kiel, Germany

^b Department of Medical Microbiology and Immunology, University of Wisconsin-Madison, 1550 Linden Drive, Madison, WI 53706, USA



microbial ecological communities



METAORGANISMS ORIGIN AND FUNCTION OF
COLLABORATIVE RESEARCH CENTRE 1182

Metaorganism

Maureen A. O'Malley

Definition

A metaorganism is the community of interacting biological entities that is indicated by a **metagenome**. A variety of **highthroughput** and other techniques are used to understand the role metaorganismal interactions play in host physiology and local and global biogeochemistry.

**broadest term:
loose interdependent
relations**

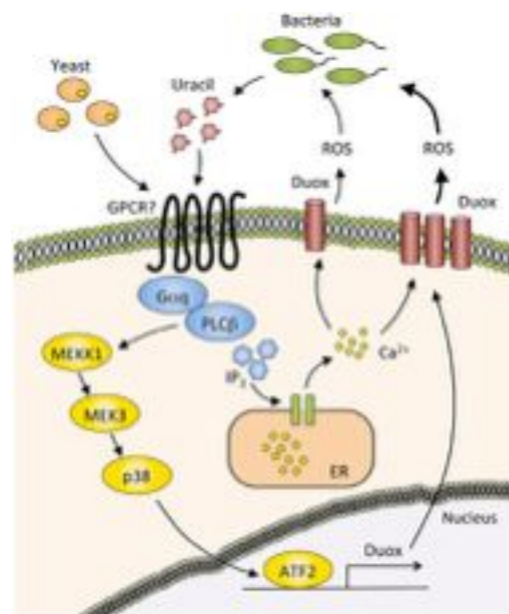
Two Major Questions

who's controlling who?

network of causal relations

local mechanisms

method: experimental

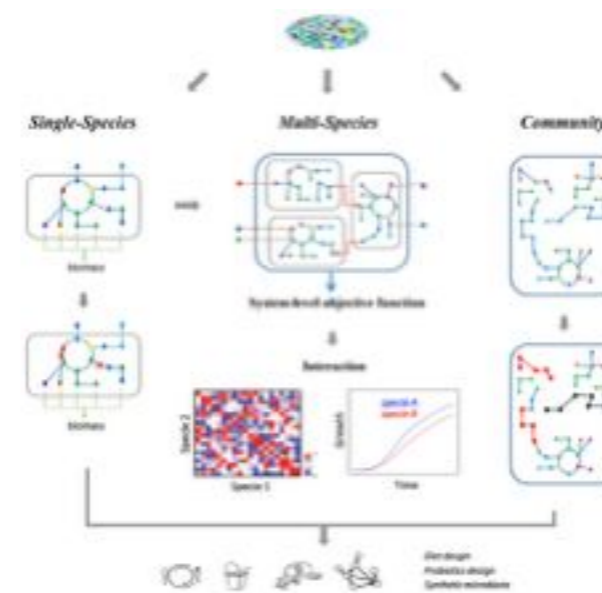


(Kuraishi et al 2013)

pathways

systems models

method: metagenomics,
model building via
organizational principles



(Ji and Nielsen 2015)

metabolic networks

who, I mean *who*????

unit of biological organization
(developmental, ecological, evolutionary)

Anatomical
Developmental
Physiological
Genetic
Immune
Evolutionary
criteria of individuality

VOLUME 87, No. 4 THE QUARTERLY REVIEW OF BIOLOGY DECEMBER 2012



A SYMBIOTIC VIEW OF LIFE: WE HAVE NEVER BEEN INDIVIDUALS

SCOTT F. GILBERT

Department of Biology, Swarthmore College
Swarthmore, Pennsylvania 19081 USA
Biotechnology Institute, University of Helsinki
00014 Helsinki, Finland

E-MAIL: SGILBER1@SWARTHMORE.EDU

JAN SAPP

Department of Biology, York University
Toronto, Ontario M3J 1P3 Canada

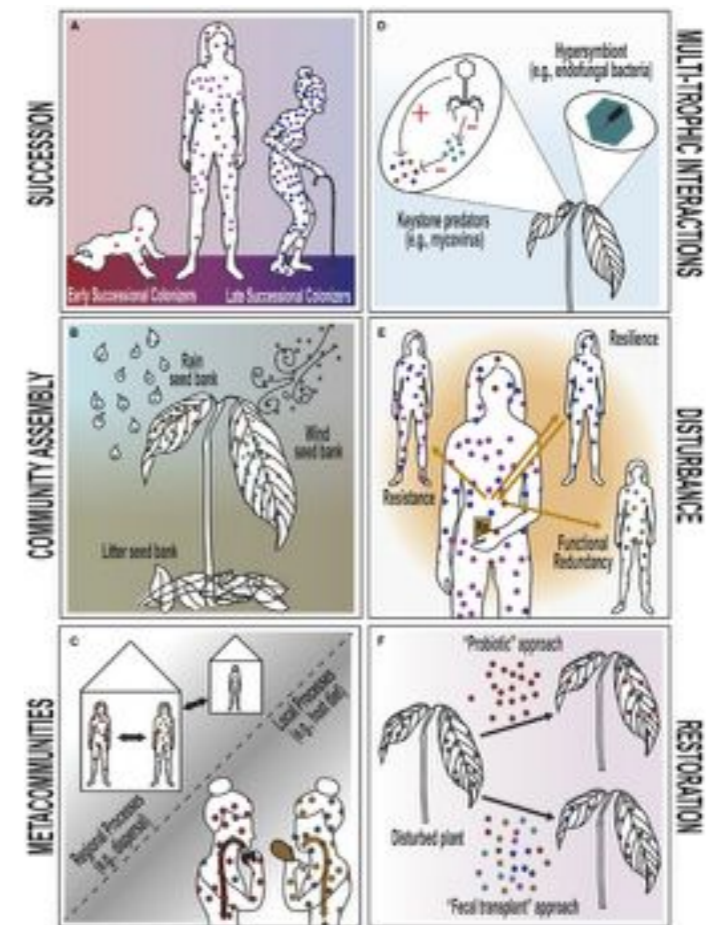
E-MAIL: JSAPP@YORKU.CA

ALFRED I. TAUBER

Department of Philosophy, Boston University
Boston, Massachusetts 02215 USA

E-MAIL: AIT@BU.EDU

community ecology theory



(Christian et al. 2015)

Internalism vs. Externalism

INTERNAL

**mentalism
nativism
(Chomsky)**

Nature

genetic program

***Preformationists*
(pre-determined form)**

***Unity of Type*
(structuralists,
development constraints)**

Psychology

Development

Evolution

EXTERNAL

**behavioralism
associationism
(Watson, Skinner)**

Nurture

environment

***Epigenesists*
(environmental determination)**

***Conditions of Existence*
(functionalists,
adaptationists)**

“What Kind of Interactionism Instead?”

Lessons from the Debates

who????

unit of biological organization
(developmental, ecological, evolutionary)

Anatomical
Developmental
Physiological
Genetic
Immune
Evolutionary
criteria of individuality

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A SYMBIOTIC VIEW OF LIFE: WE HAVE NEVER BEEN INDIVIDUALS

SCOTT F. GILBERT

Department of Biology, Swarthmore College
Swarthmore, Pennsylvania 19081 USA
Biotechnology Institute, University of Helsinki
00014 Helsinki, Finland

E-MAIL: SGILBER1@SWARTHMORE.EDU

JAN SAPP

Department of Biology, York University
Toronto, Ontario M3J 1P3 Canada

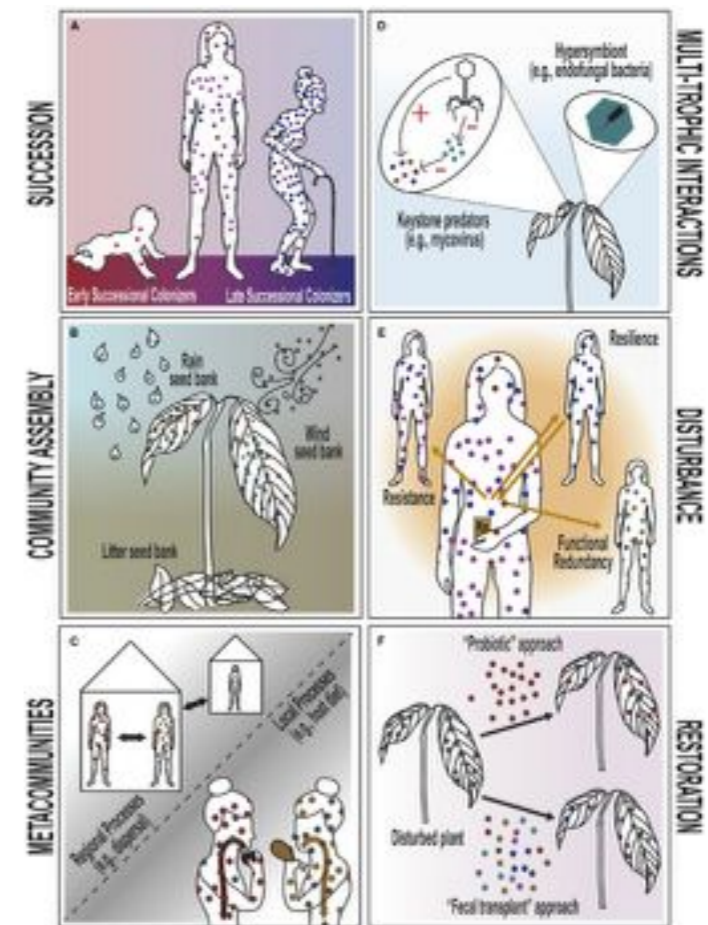
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ALFRED I. TAUBER

Department of Philosophy, Boston University
Boston, Massachusetts 02215 USA

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community ecology theory



(Christian et al. 2015)

First Lessons

“The Extended Mind”
Clark and Chalmers (1998)



*[[Authors are listed in order of degree of belief in the central thesis.]]

parity argument

1. equivalence principle

e.g.  = functionally  (internal to X)

2. coupling criteria

e.g.  is coupled with 

3. parity thesis:

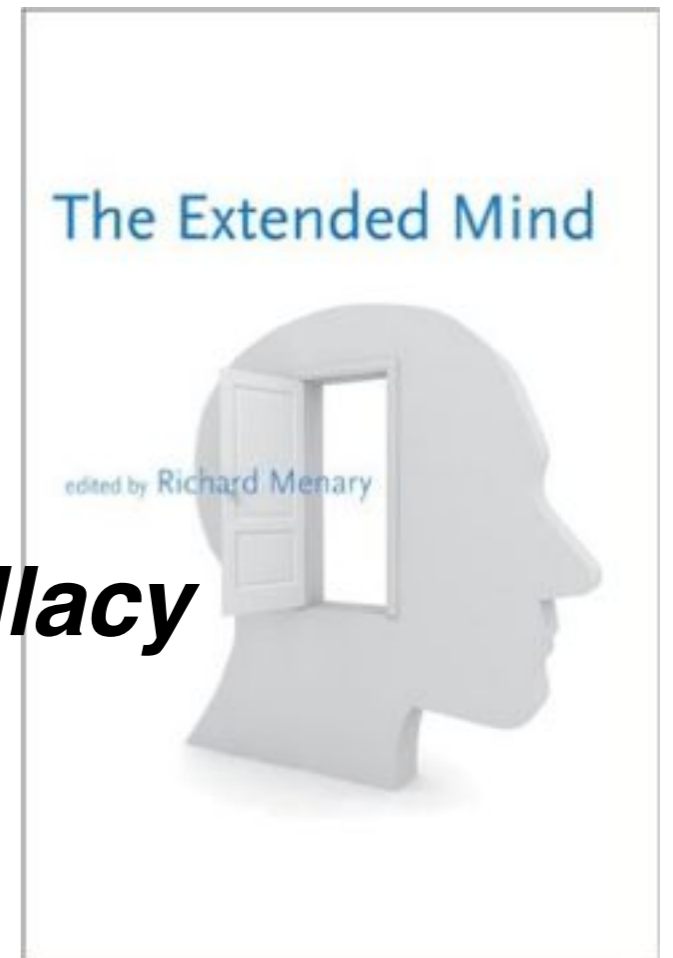
e.g. given 1 & 2, if  were internal  would be seen as cognitive (or part of 's mind)



causal coupling - constitution fallacy



causal coupling - constitution fallacy *fallacy*



~~3. parity thesis:~~

~~e.g. given 1 & 2, if A were internal, A would be seen as cognitive (or part of X's mind)~~

3. a model of the mental:

A has "the mark," therefore A is part of the mind

Lesson #1 : “Parity Arguments” are anti-bias Heuristics

veil of ignorance test

parity thesis: if A were internal, A would be seen as cognitive (or part of X’s mind)

Anatomical

Developmental

Physiological

Genetic

Immune

Evolutionary

criteria of individuality

VOLUME 87, No. 4

THE QUARTERLY REVIEW OF BIOLOGY

DECEMBER 2012



A SYMBIOTIC VIEW OF LIFE: WE HAVE NEVER BEEN
INDIVIDUALS

Lesson #1 : “Parity Arguments” are anti-bias Heuristics

veil of ignorance test

parity thesis: if A were internal, A would be seen as cognitive (or part of X’s mind)

a model of the individual/mind

A has “the mark,” therefore A is part of the mind

complimentary criteria

A compliments the mind for the mind to perform or develop

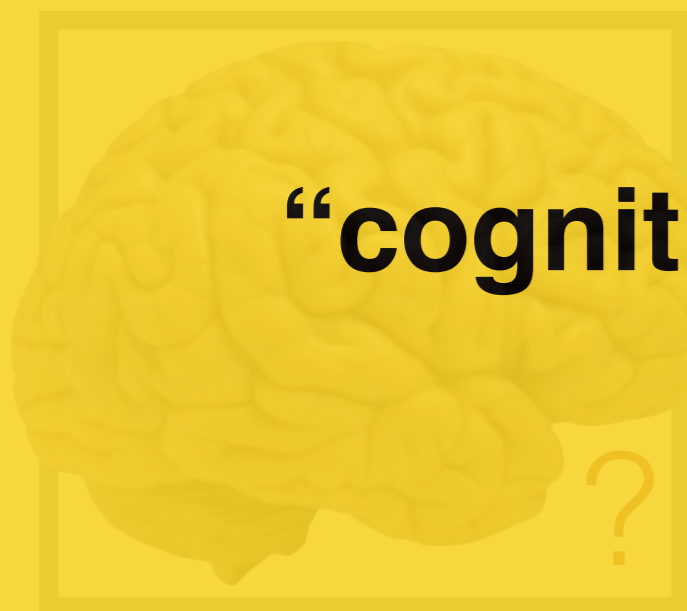
the enactive approach

Making Sense of Sense-Making: Reflections on Enactive and Extended Mind Theories

Evan Thompson · Mog Stapleton

- do not start with what's internal to the skull
- instead start with how a system must be organized in order to be autonomous

“cognition” does not have a location



the constituents:
recursively depend on each other,
sustain the system as a unity,
determine a domain of possible
interactions with the world

a **thermodynamically open** system with **operational closure** that actively generates and sustains its identity under precarious conditions (Di Paolo and Izuka 2008, Thompson 2007, Varela 1979, 1997)

Lesson #2 : Solutions can Change Frameworks and Shift Research Questions

“cognition” does not have a location

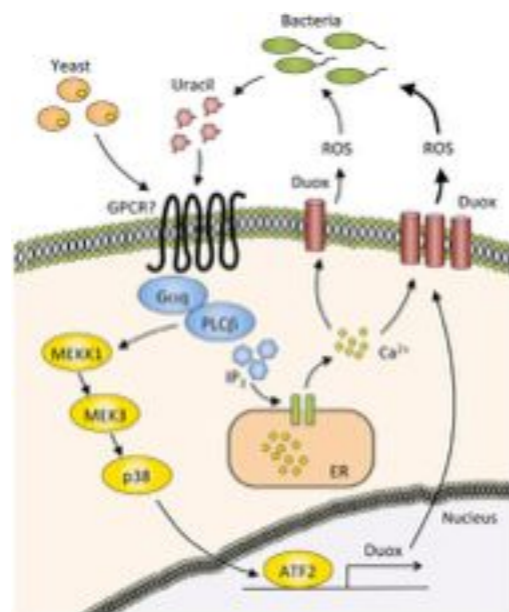
changes the definition of “cognition”

who's controlling who?

network of causal relations

local mechanisms

method: experimental

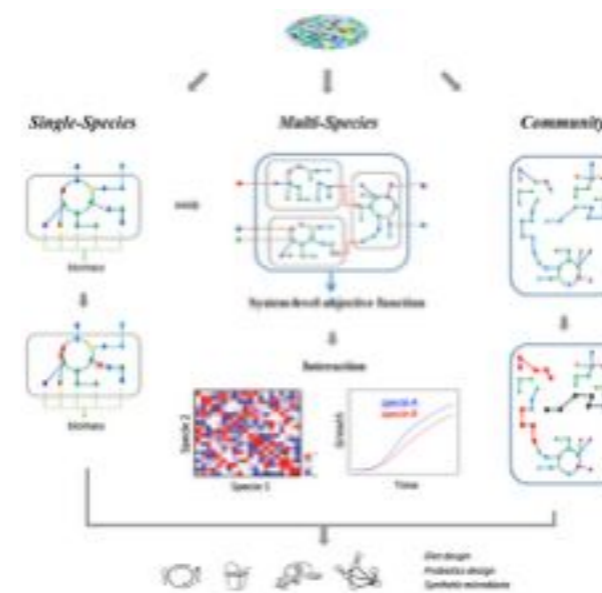


(Kuraishi et al 2013)

pathways

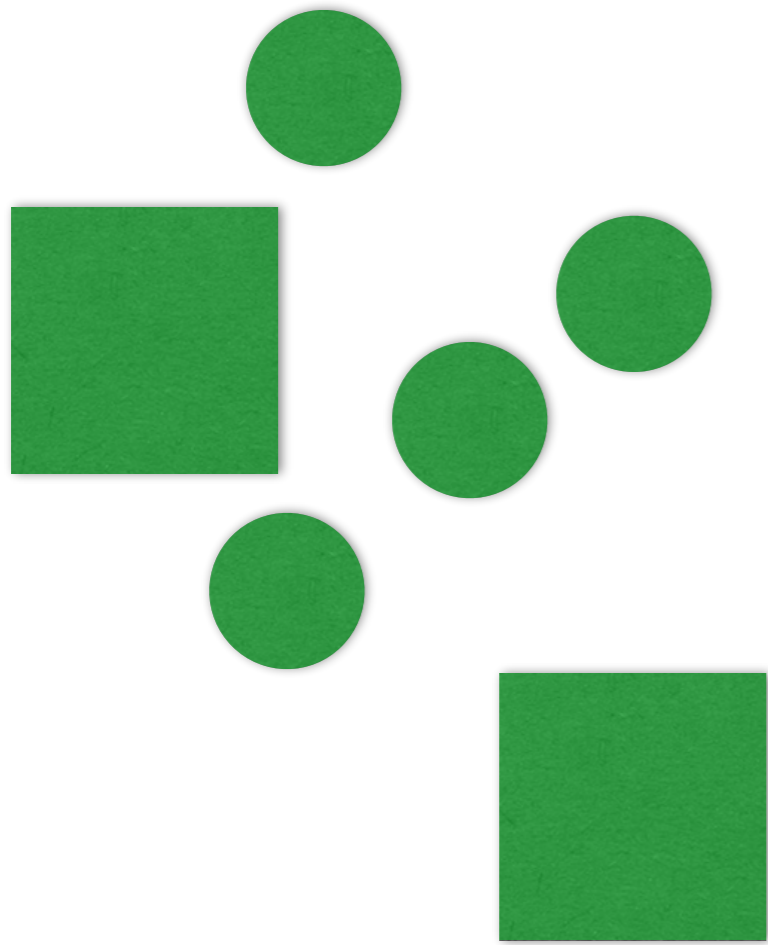
systems models

method: metagenomics,
model building via
organizational principles

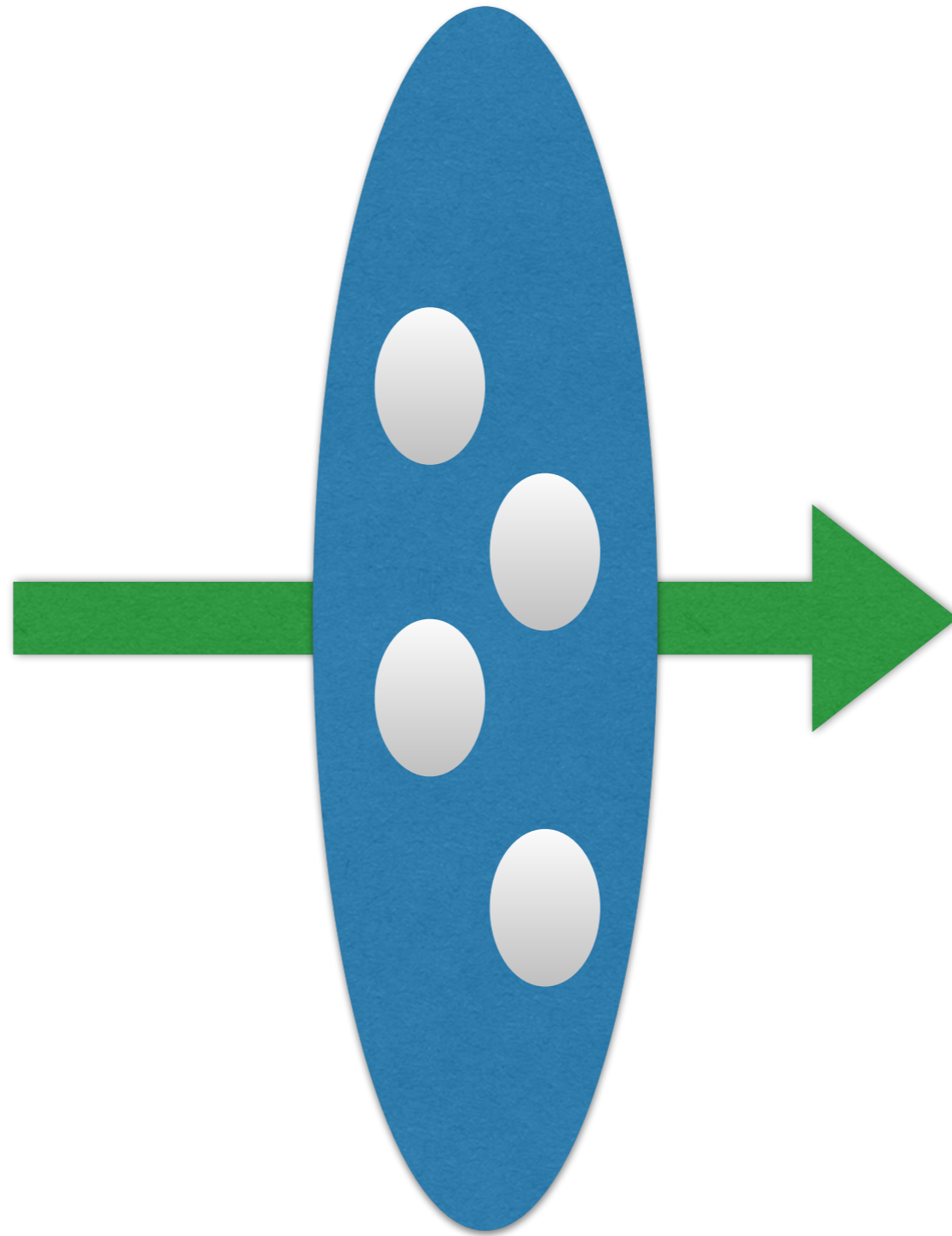


(Ji and Nielsen 2015)

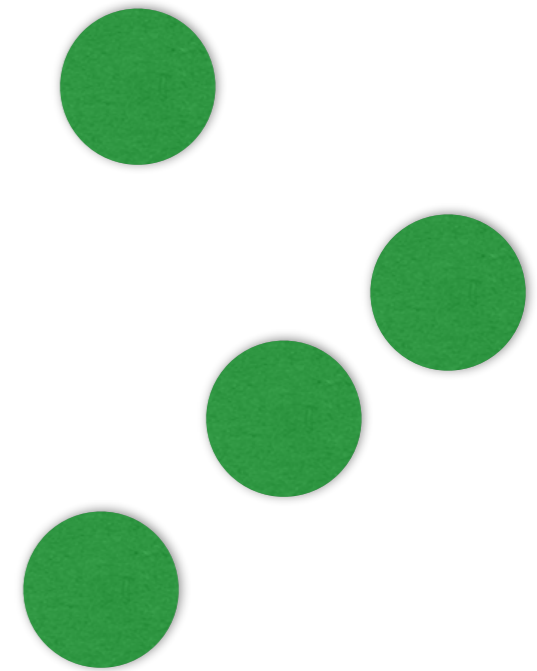
metabolic networks

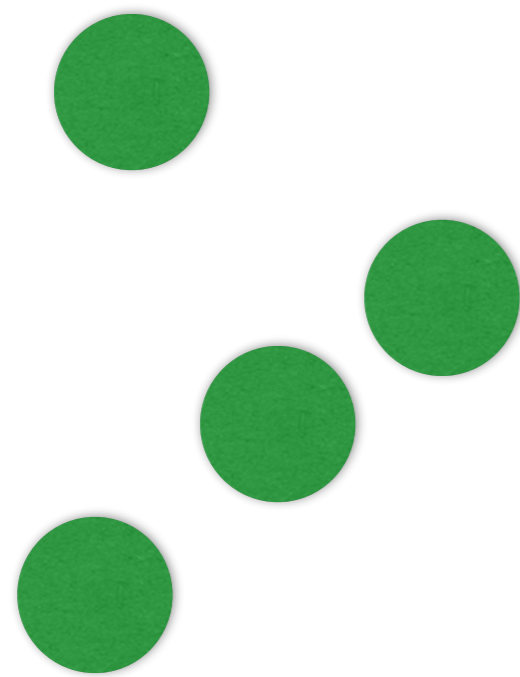


**the internal
systems vary**



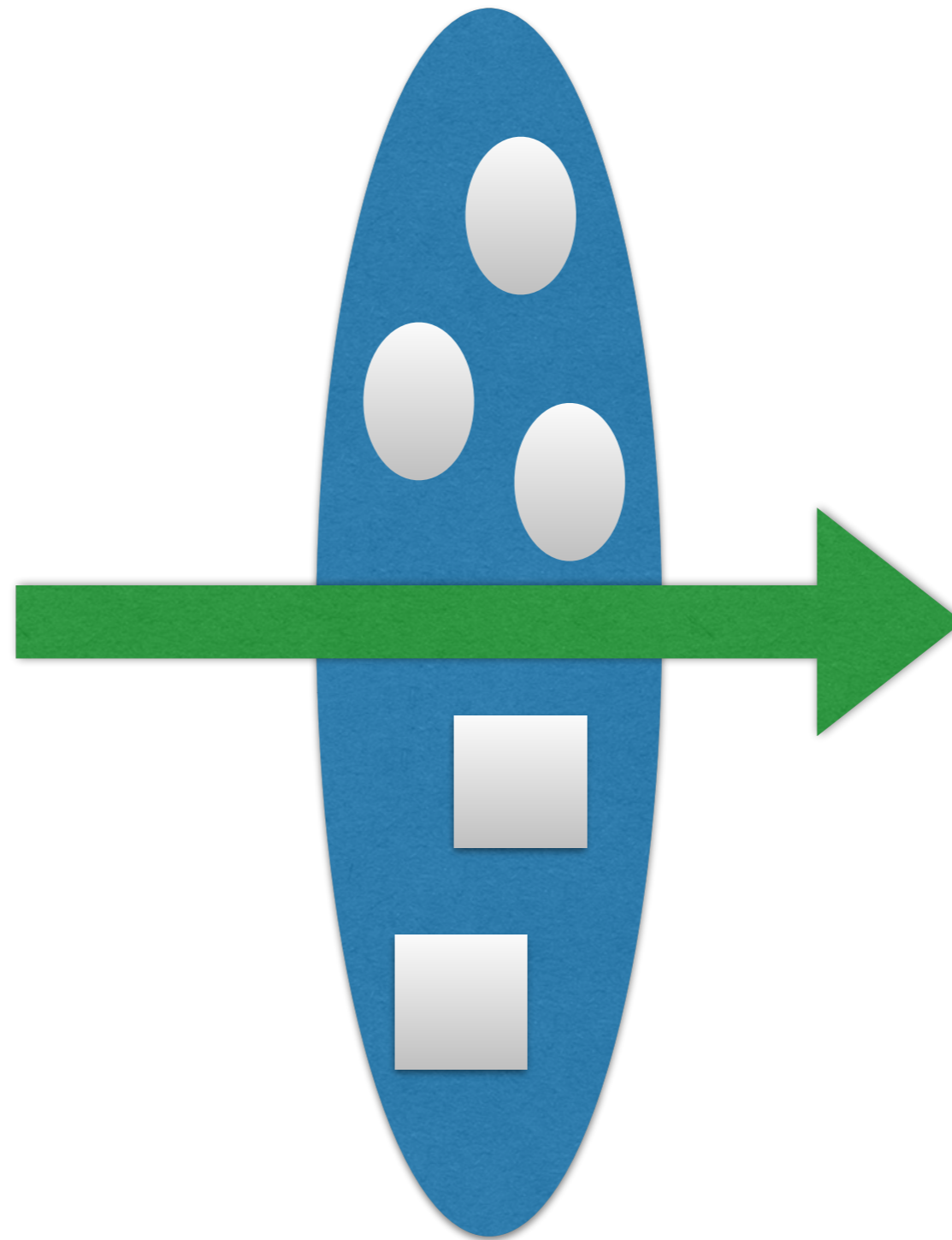
**the environment
selects**



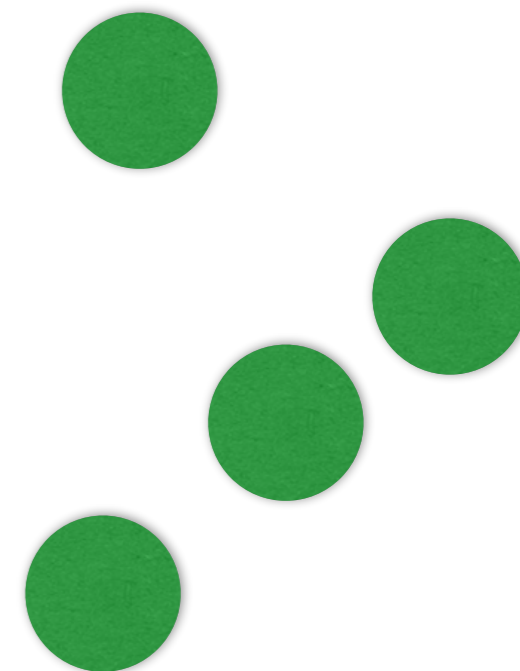


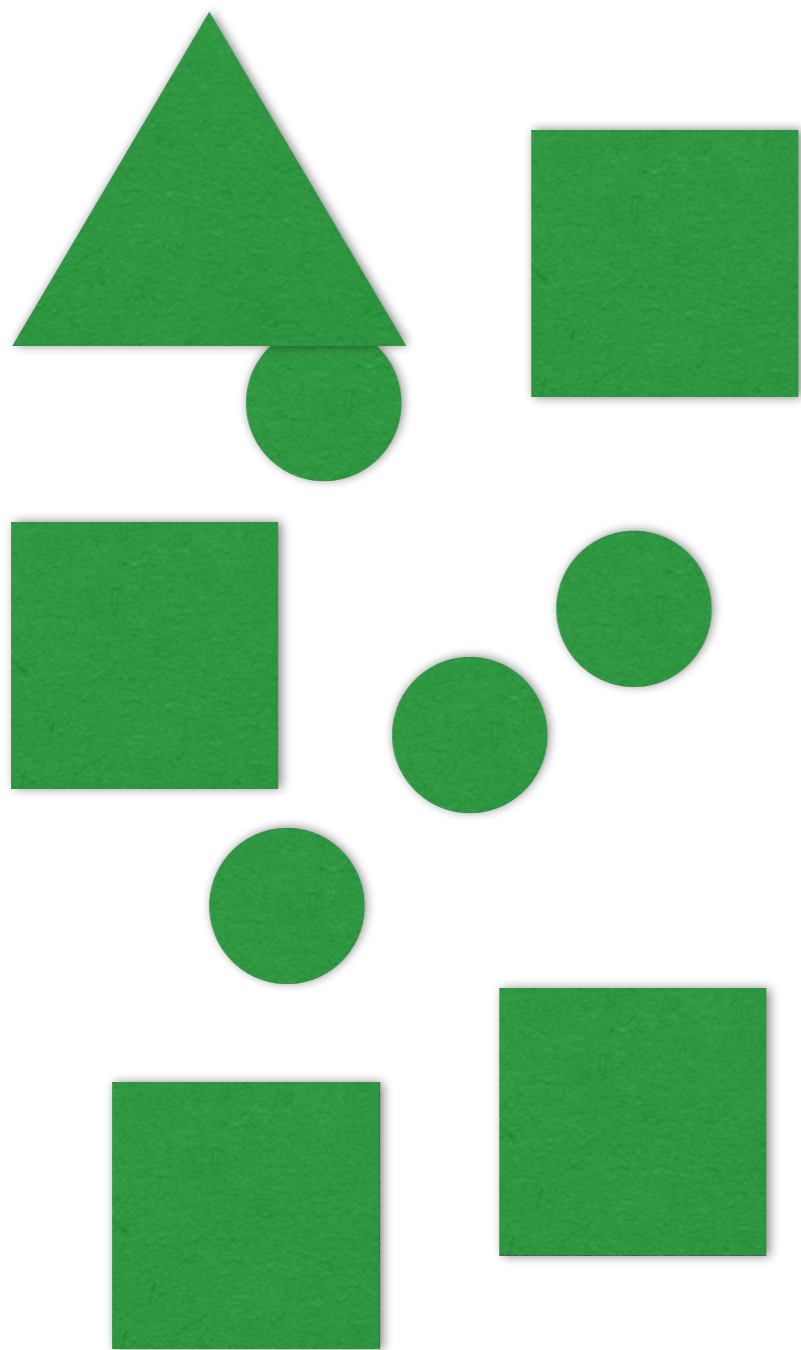
**developmental
constraints?**

**the internal
systems vary**

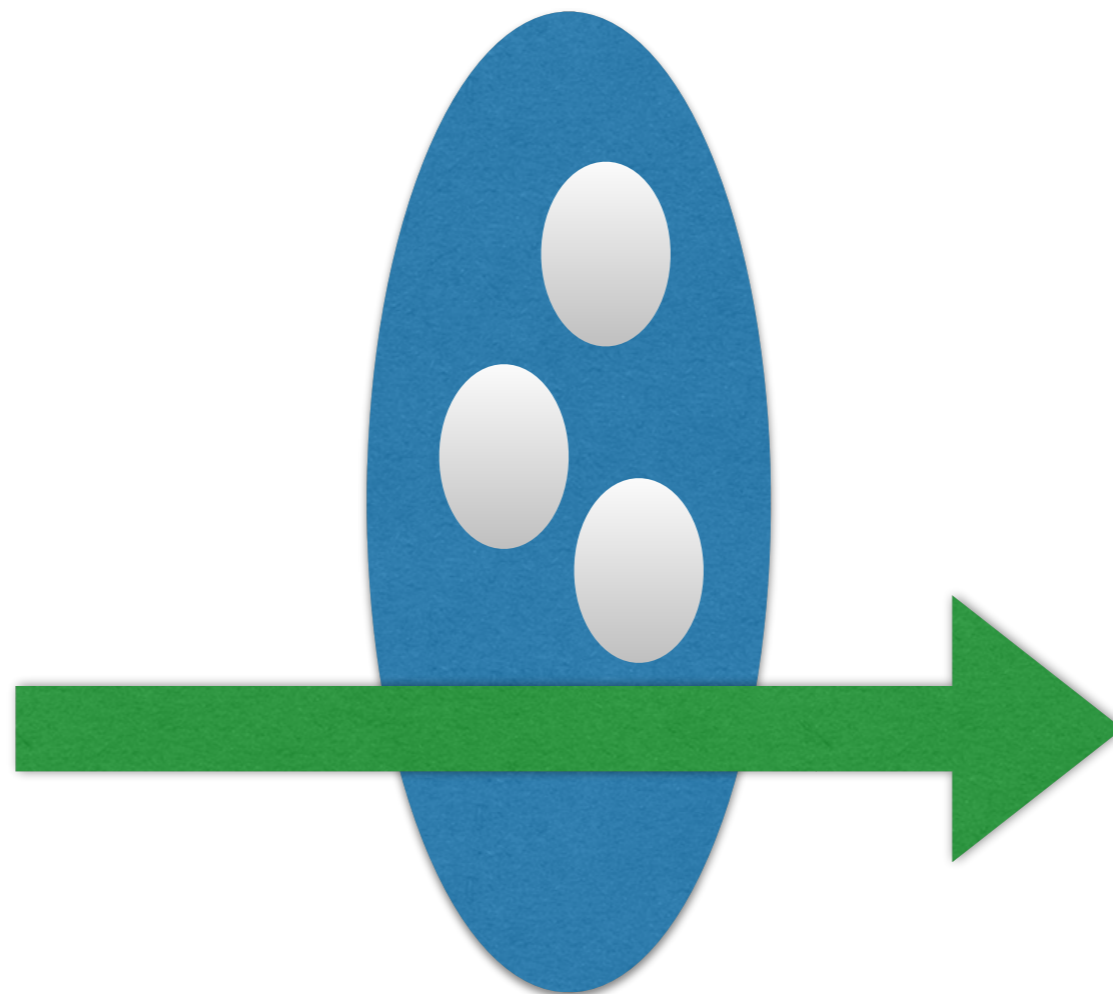


**the environment
selects**



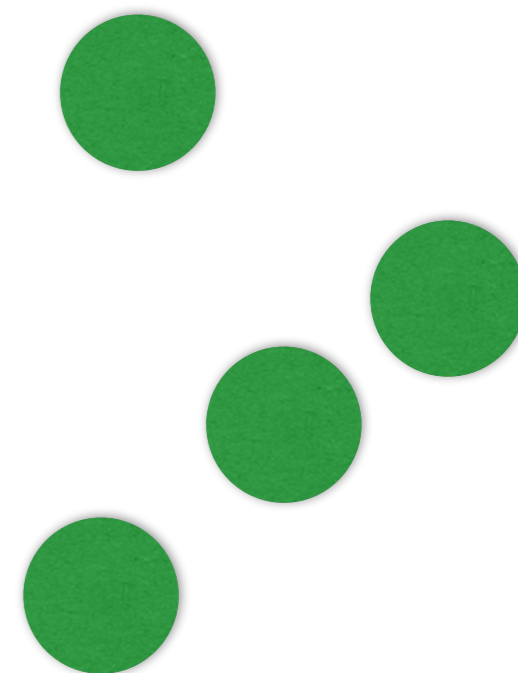


**the internal
systems vary**



**strong
selection?**

**the environment
selects**



How strong is selection?

detection methods:

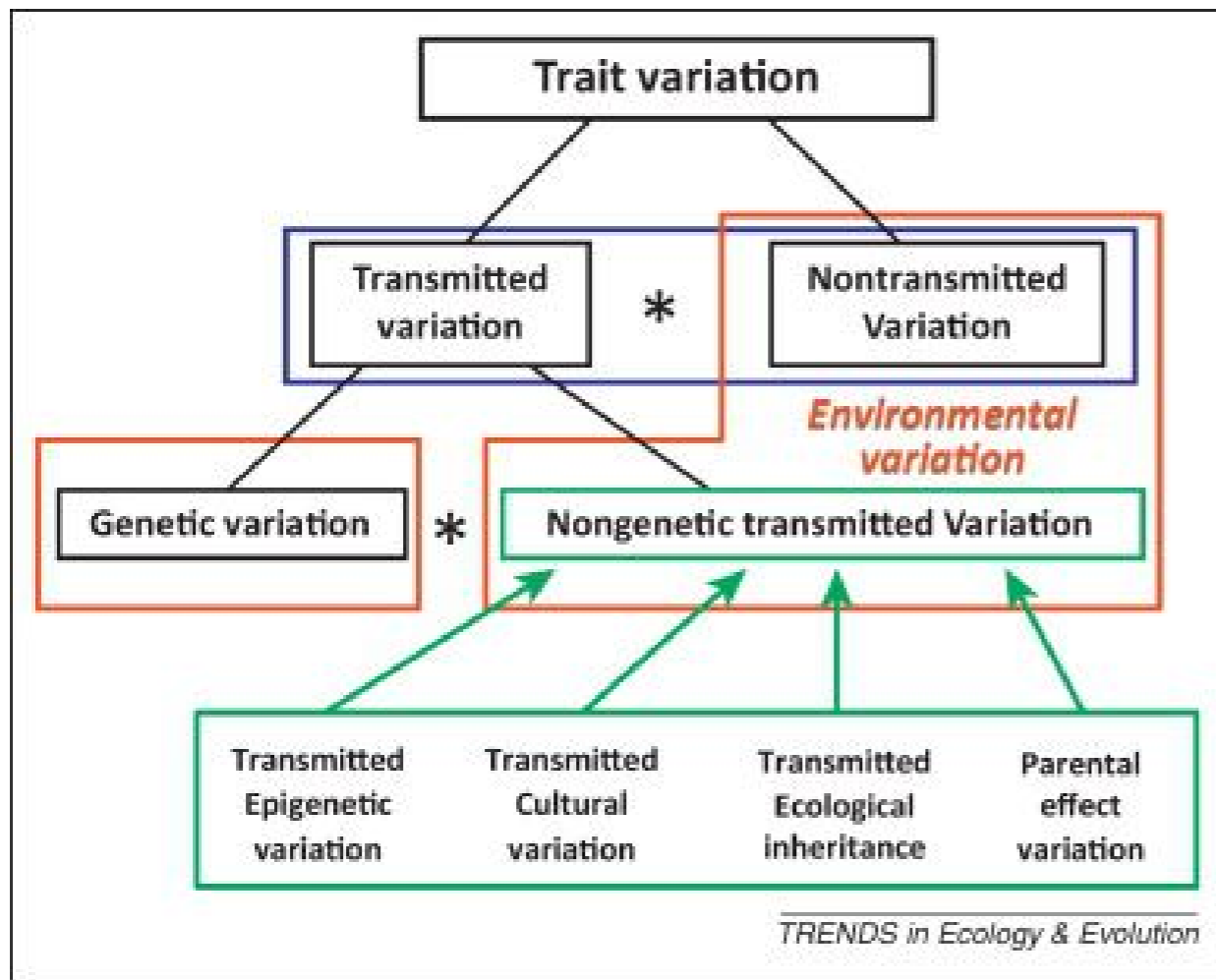
- (1) by seeking correlation between environment and trait/trait distribution/genetic signatures,
- (2) by comparing actual evolution against formal "null" models where *no* selection is assumed to occur,
- (3) by comparing actual evolution against formal "null" models where *only* selection is assumed to occur,
- (4) by detecting and confirming stable equilibrium,
- (5) by using controlling environmental conditions to test response to one or a few selection pressures,
- (6) by tallying realized fitness, e.g, viability (actual survivorship to sexual maturity), mating success (actual number of mates), fertility (average number of offspring),⁷⁰ etc.

John Endler (1986): review up to 1983

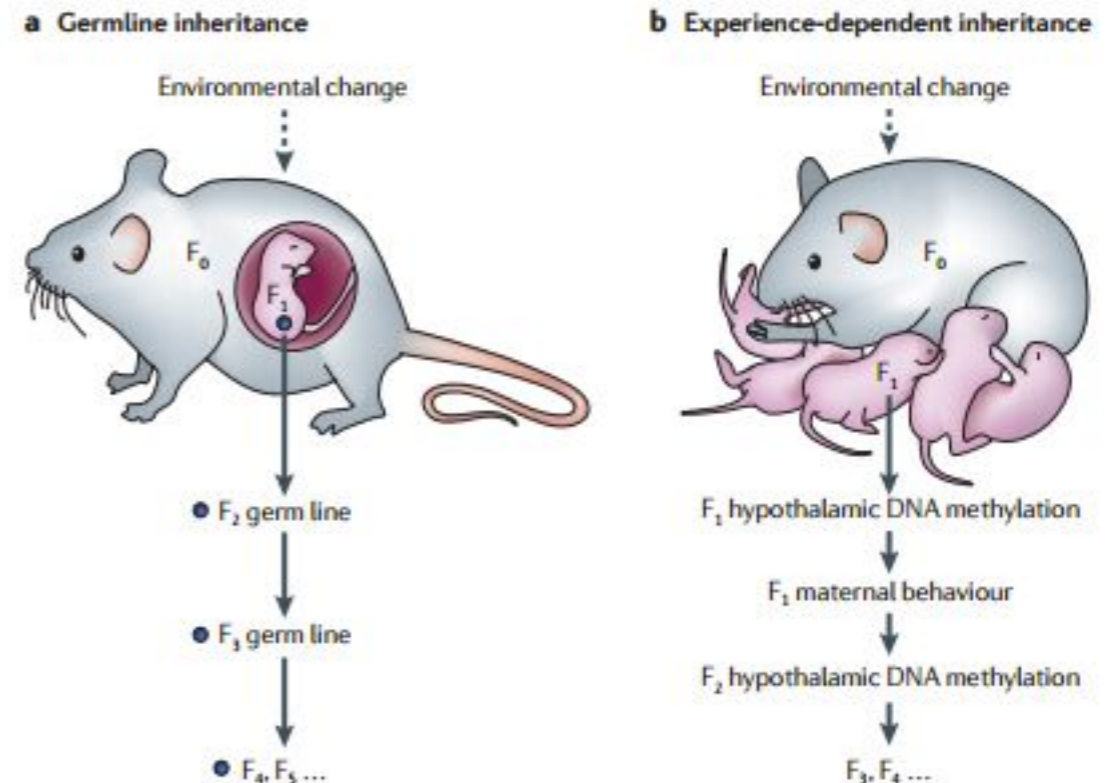
Kingsolver et al. (2001): 1984-1997

Barrett and Hoekstra (2011) : molecular data

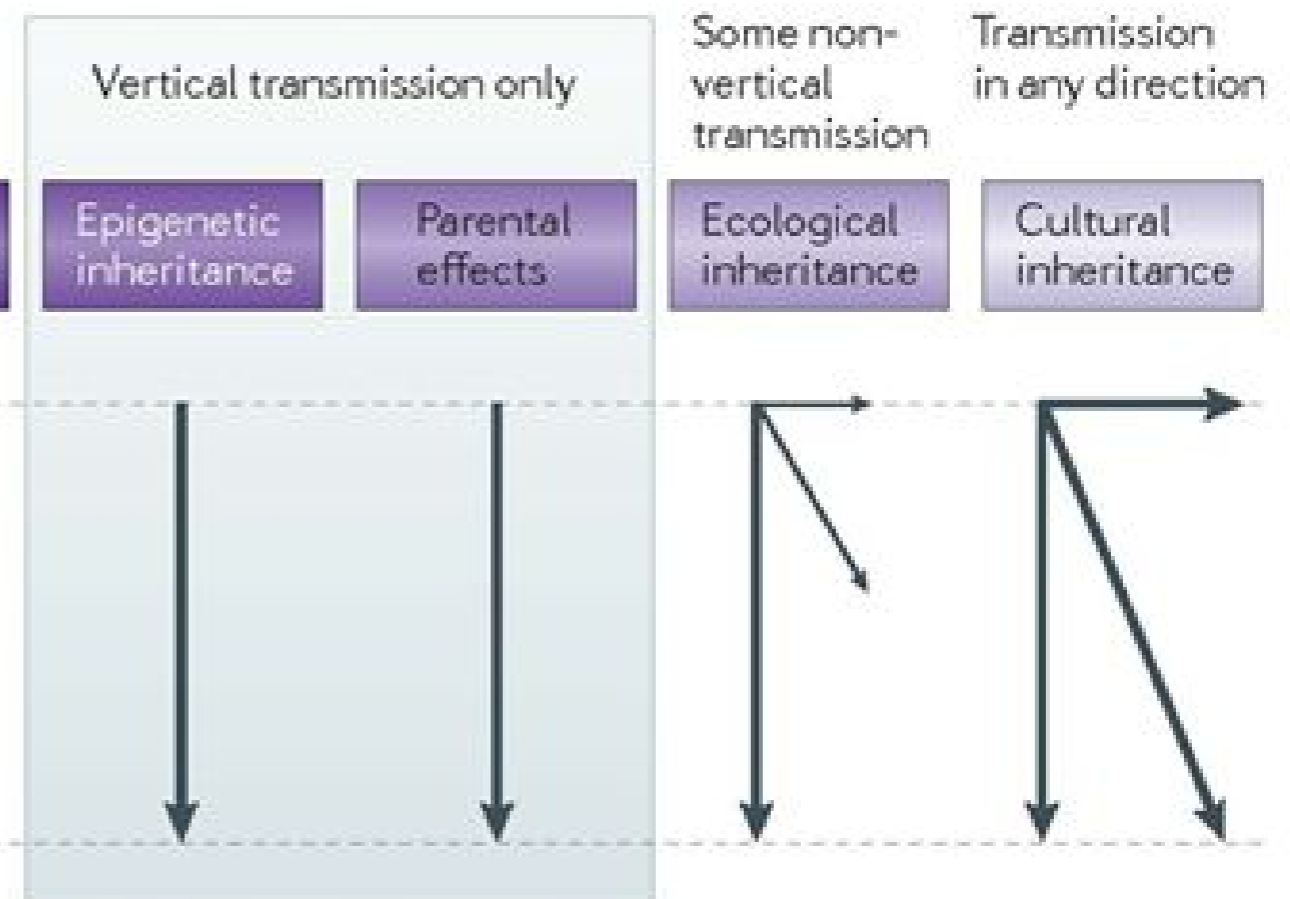
quantitative genetics methods to estimate heritability



(Danchin 2013)

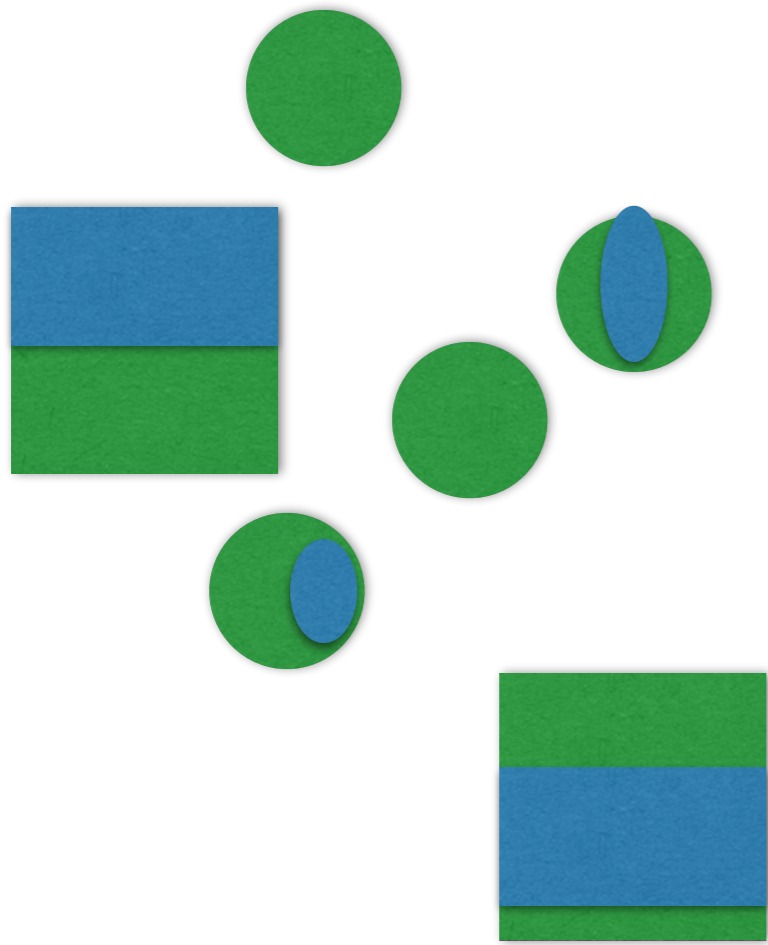


(Danchin et al 2011)

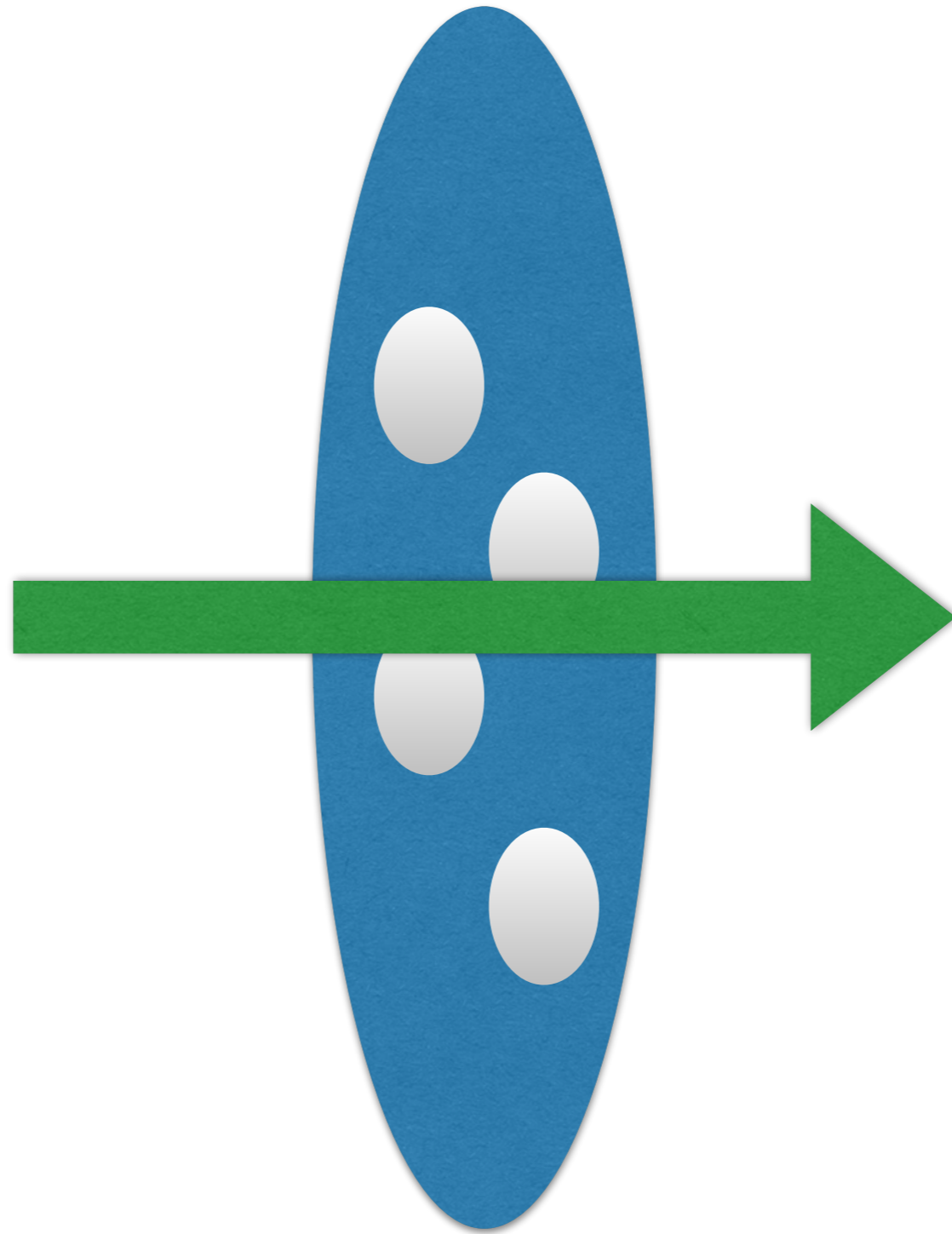


developmental mechanisms

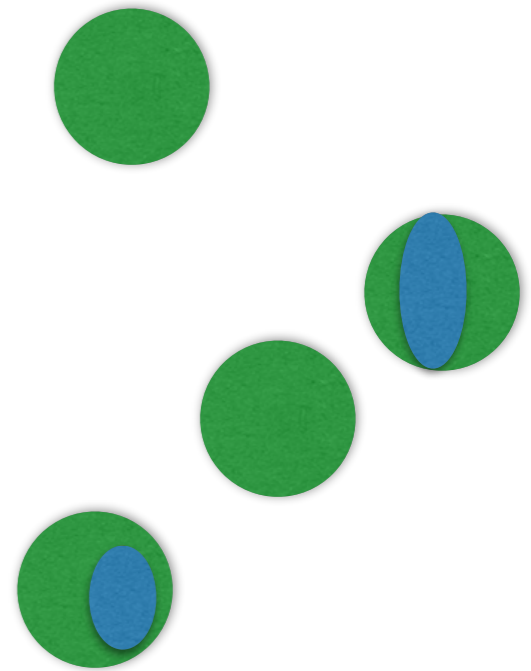
(Danchin & Pocheville 2014)

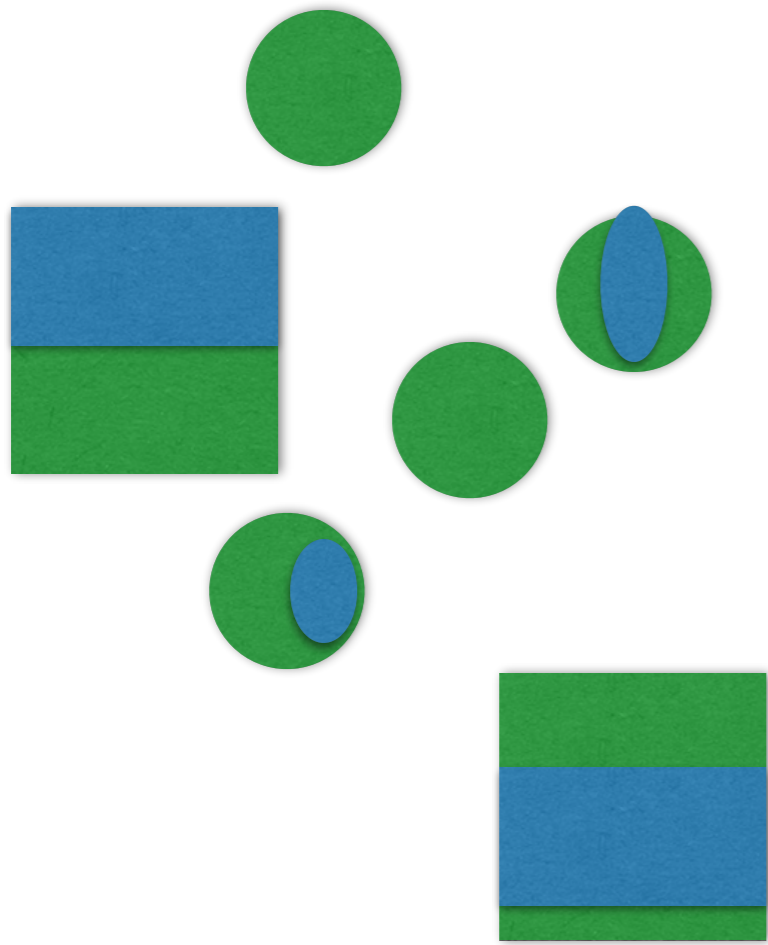


**the developing
systems vary**

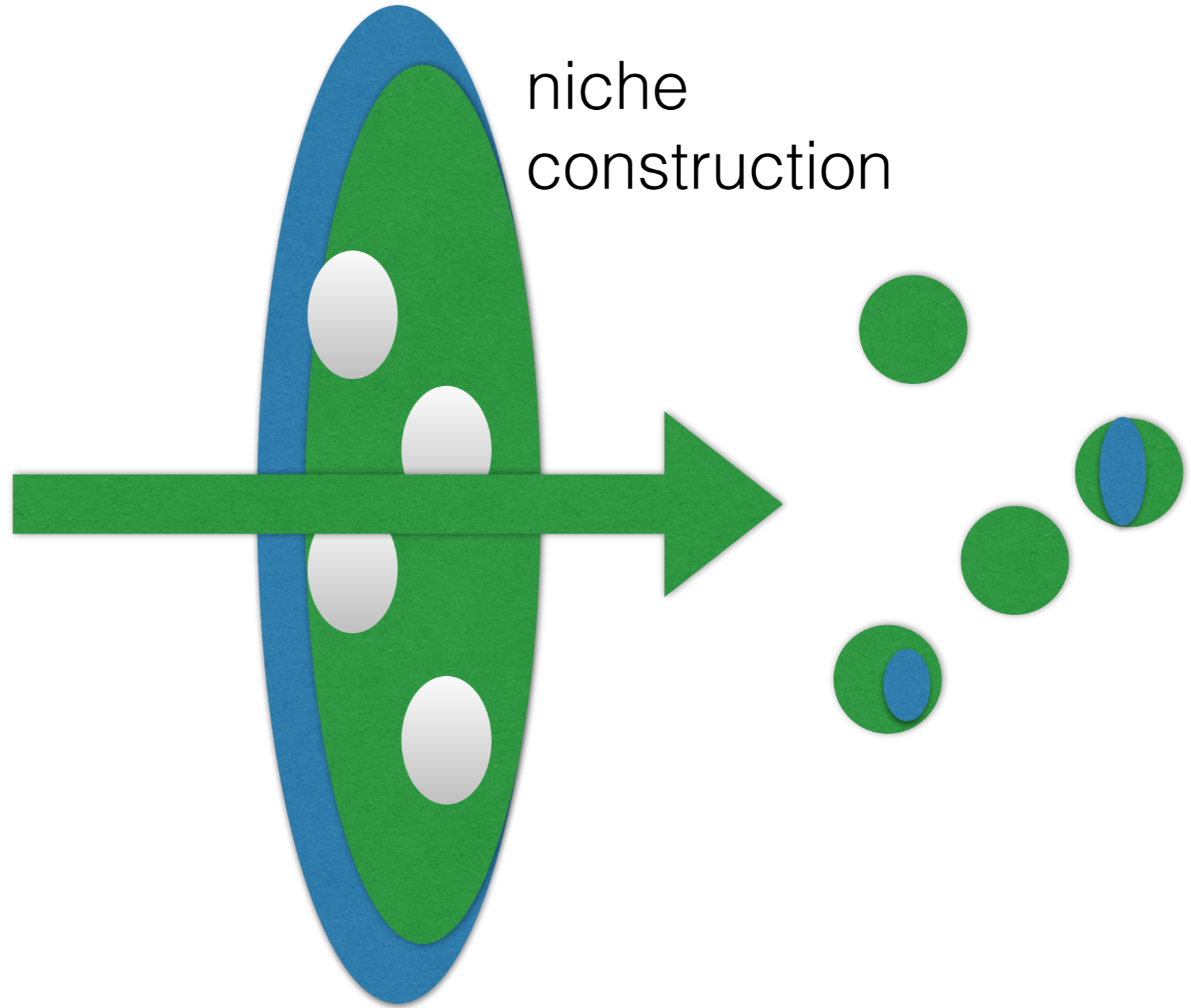


**the environment
selects**





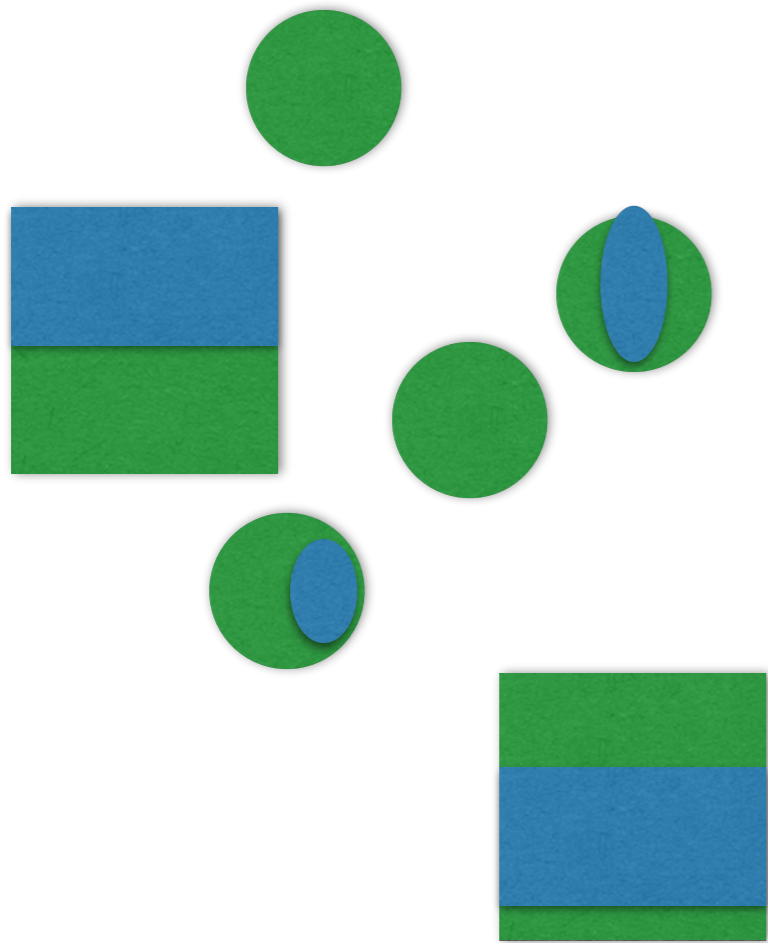
**the developing
systems vary**



**the environment
selects**

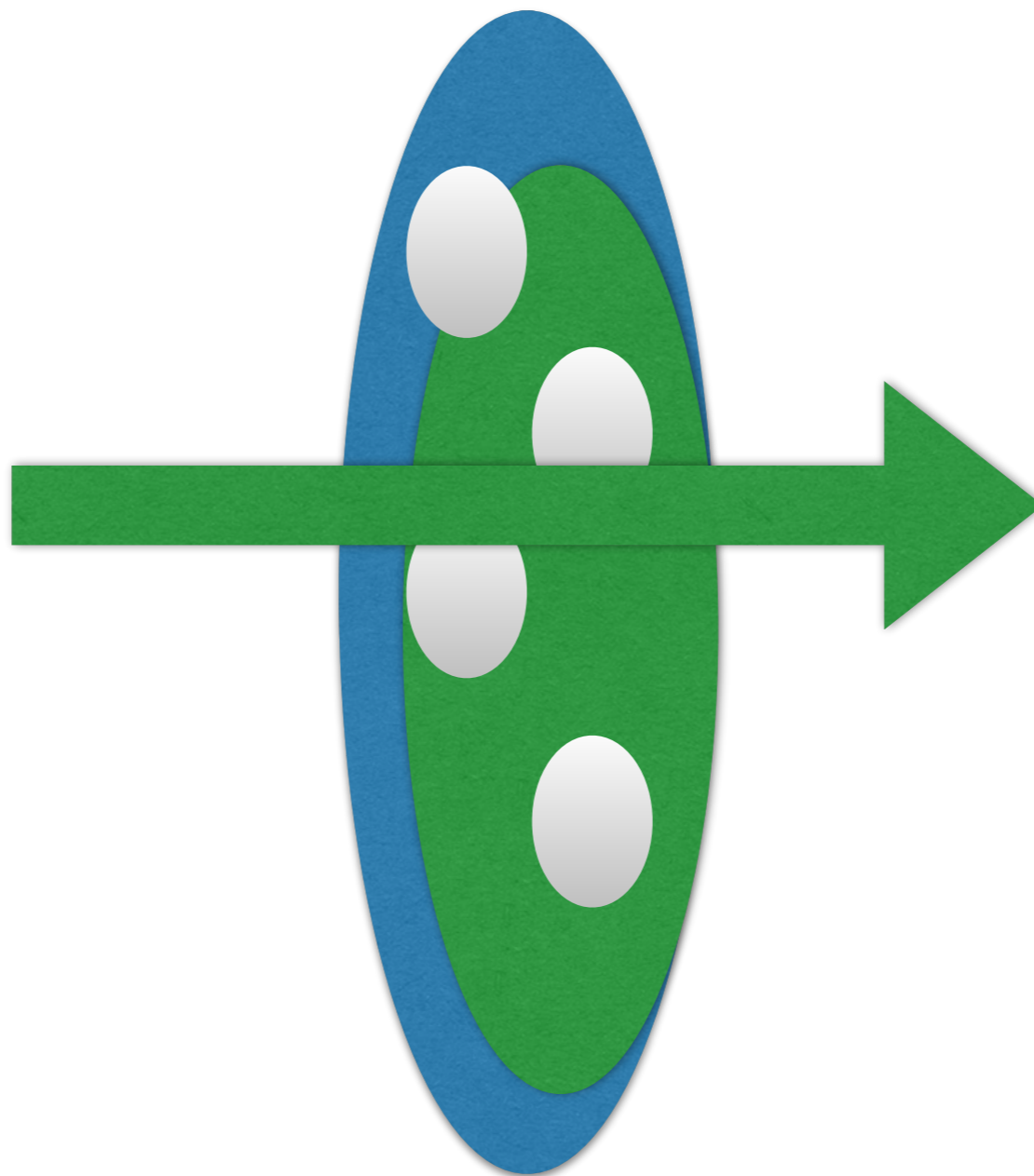
Lesson #3 : the relative *importance* of internal or external factors does not imply the relative importance of a particular explanatory *role*

developmental constraints?

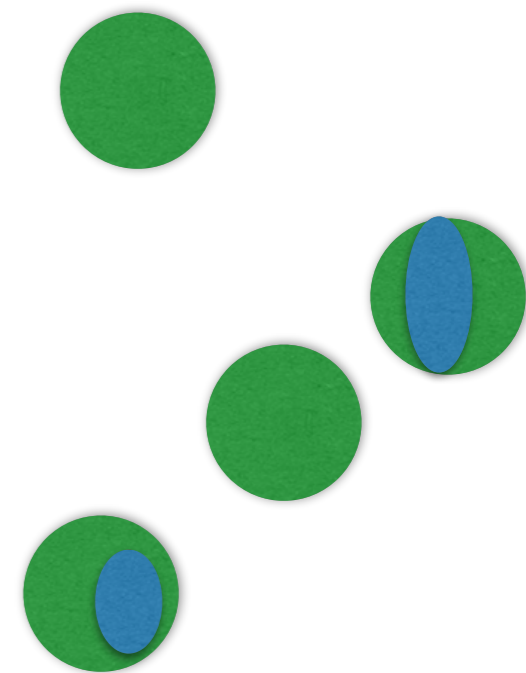


the developing systems vary

strong selection?



the environment selects



Avatars of information: towards an inclusive evolutionary synthesis

Étienne Danchin^{1,2}

¹ Centre National de la Recherche Scientifique (CNRS), Université Paul Sabatier (UPS), École Nationale de Formation Agronomique (ENFA), Laboratoire Évolution & Diversité Biologique, UMR5174, 118 route de Narbonne, F-31062 Toulouse Cédex 9, France

² Université Paul Sabatier, Laboratoire Évolution & Diversité Biologique, UMR5174; F-31062 Toulouse, France

Genetic
inheritance

Epigenetic
inheritance

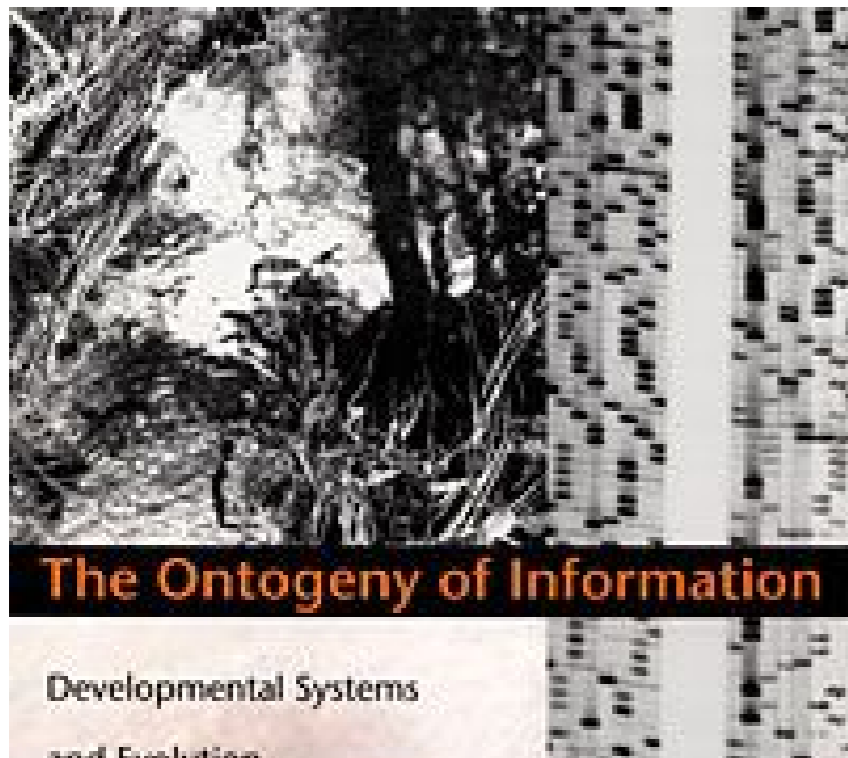
Parental
effects

Ecological
inheritance

Cultural
inheritance

Potential information becomes realized information during development

Genetic information constitutes potential information (see [21]) that is only realized when confronted by environmental information. More generally, development necessarily entails interactions between the various sources of information possessed by individuals, be they inclusively heritable [13] or not, genetic or nongenetic [14].



Not the distribution of pre-existing information that instructs development.

But the ongoing totality of interactions that regularly reproduces the developing system.

“information” is not *preformed*

With ‘Genes’ Like That, Who Needs an Environment? Postgenomics’s Argument for the ‘Ontogeny of Information’

2006

Karola Stotz†‡

environment + genes
co-specify products
information is created
instead of inherited

Lesson #2 : Solutions can Change Frameworks and Shift Research Questions

“information” is not *performed*

changes the definition of “developmental information”

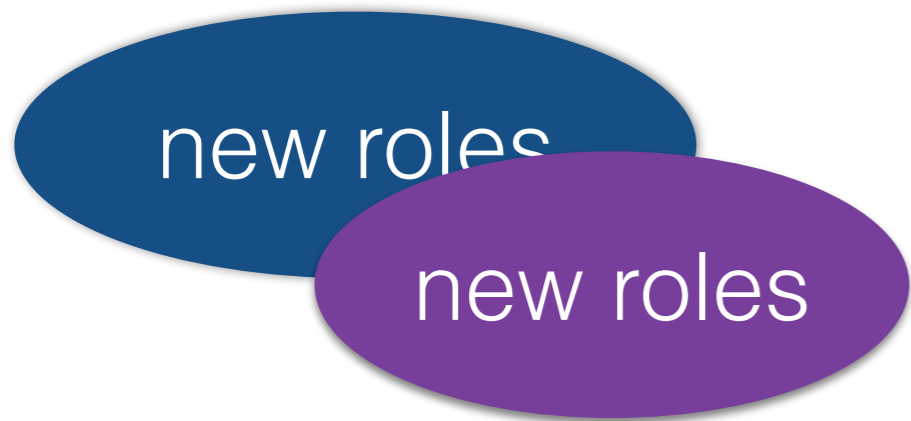
Summary of Lessons

Lesson #1 : “Parity Arguments” are anti-bias heuristics,
More criteria are needed to talk about “units.”

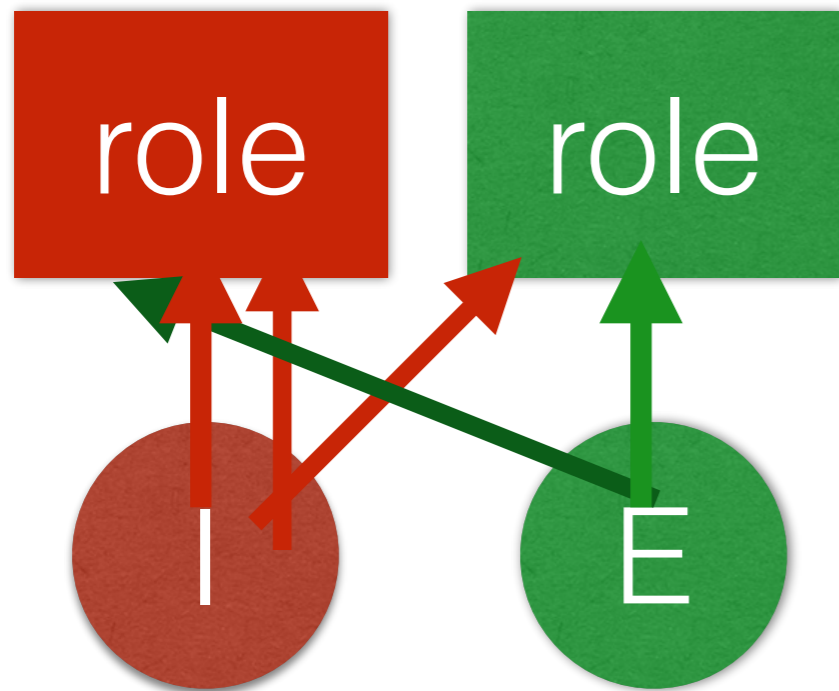
Lesson #2 : Solutions can change frameworks
and shift research questions, “information,”
“cognition/life” may change meanings and
operational definitions

Lesson #3 : The relative importance of internal or
external factors does not imply the relative
importance of a particular explanatory role

Three Interactionist Responses



change framework &
research questions

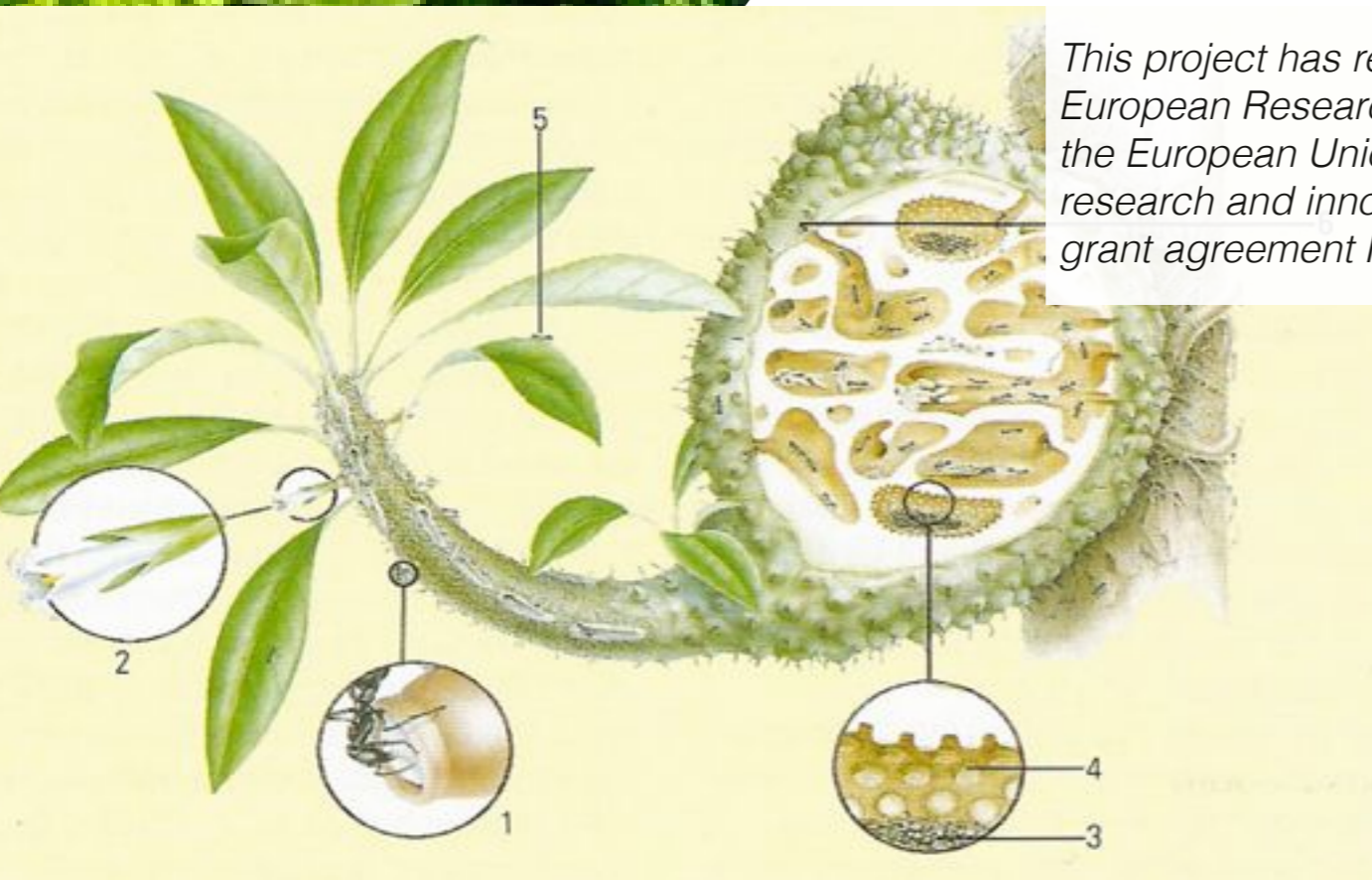


re-assign roles to internal/
external

shift importance of internal/
external without changing their
assigned roles



caveat &
Thank You



This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme-grant agreement № 637647 - IDEM

