

Biological asymmetry and evolution

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Asymmetry in biology in three stories

Introduction: symmetry and asymmetry from molecules to organisms

- **Development**

How to make asymmetrical organisms?

- **Evolution**

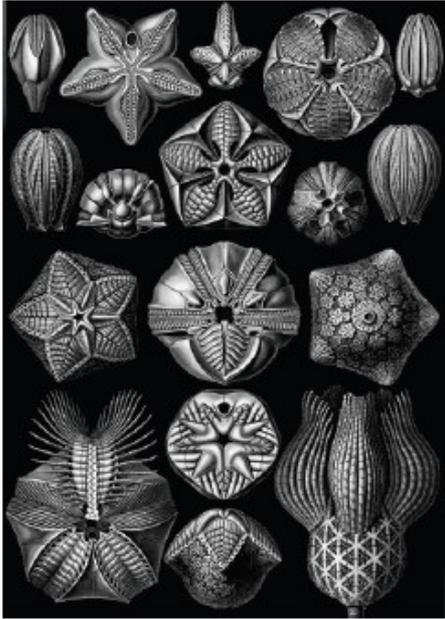
How does asymmetry evolve?

What does it tell us about evolutionary processes?

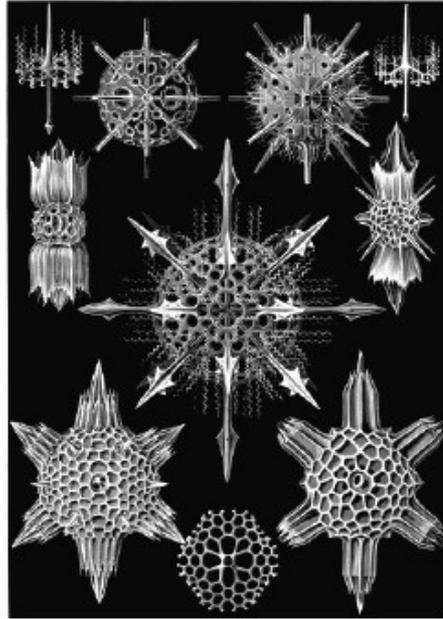
- **Social sciences**

The use and abuse of Fluctuating asymmetry

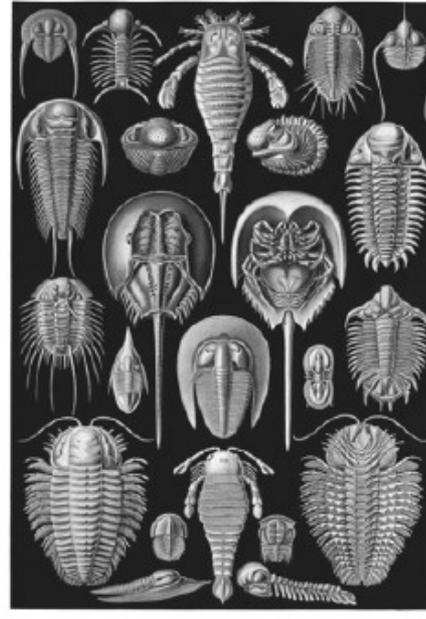
Radial symmetry



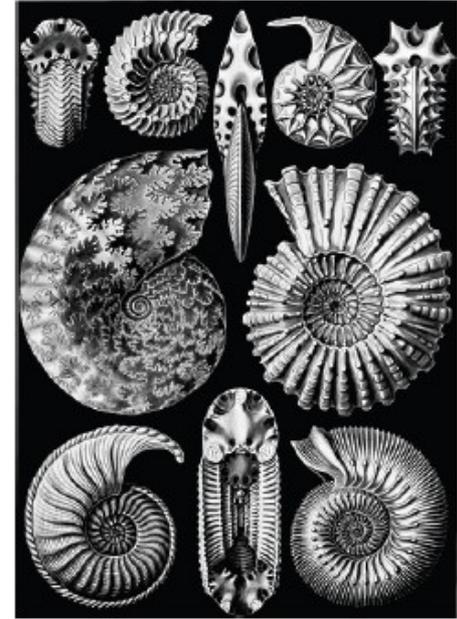
Bilateral symmetry and radial symmetry



Serial homology



Spiral symmetry

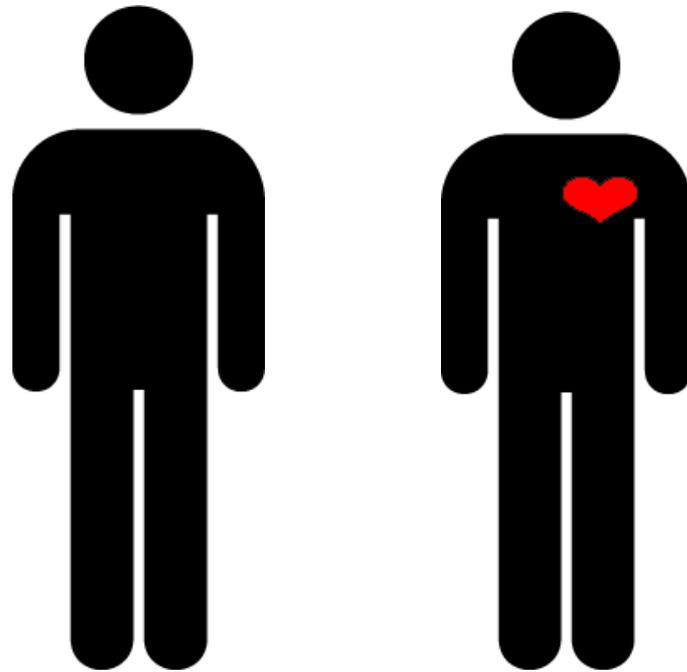


Helical symmetry



Diversity of types of biological symmetries

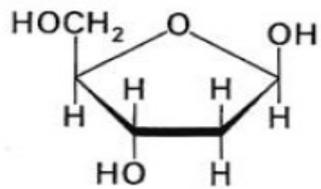
Bilateral symmetry (and asymmetry!)



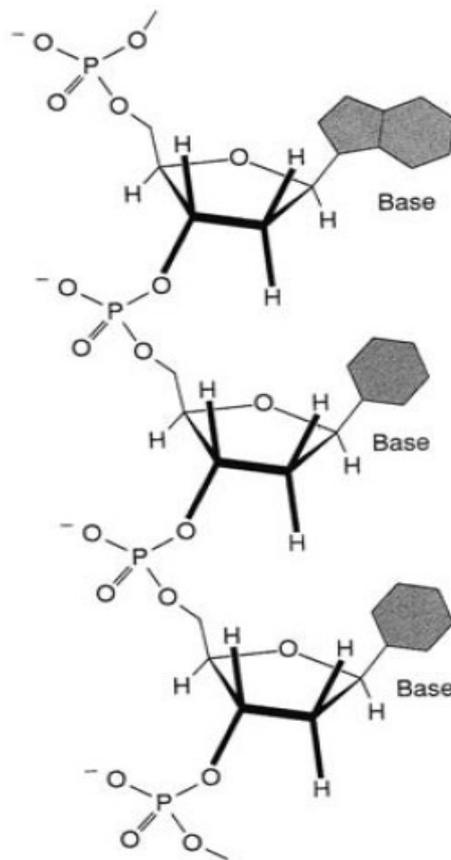
Asymmetric molecules: homochirality in living organisms

Louis Pasteur (1860):

‘This was perhaps the only well-marked line of demarcation that can at present be drawn between the chemistry of dead and living matter’



D-deoxyribose



DNA



Right-handed B-type
DNA double helix

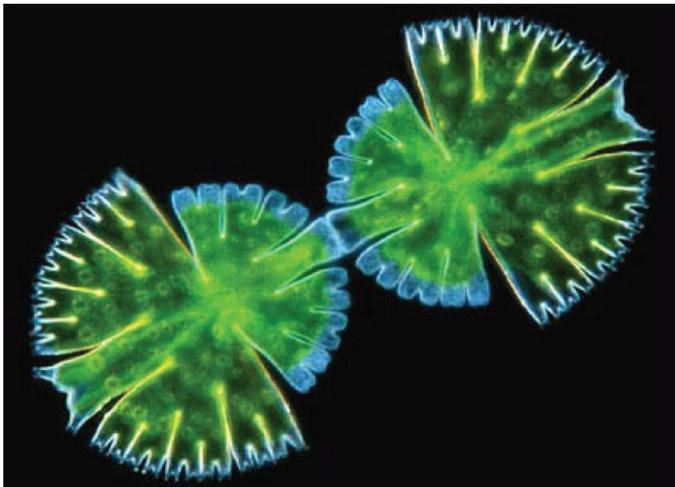
Relevance for higher levels of symmetry/asymmetry?

Symmetry and asymmetry in unicellular organisms

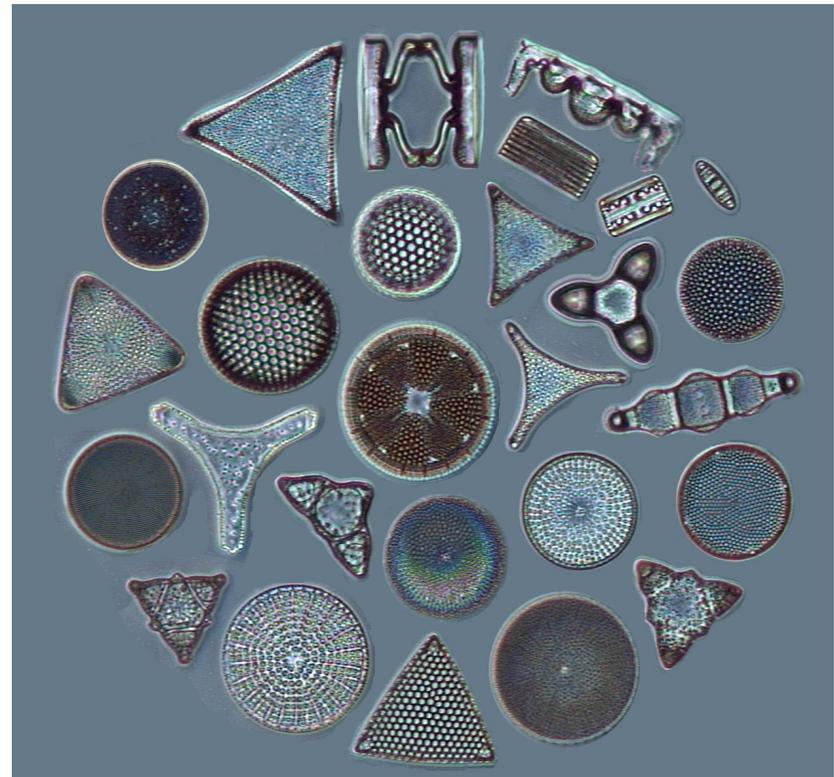
Cristal-like structures

Development? Functions?

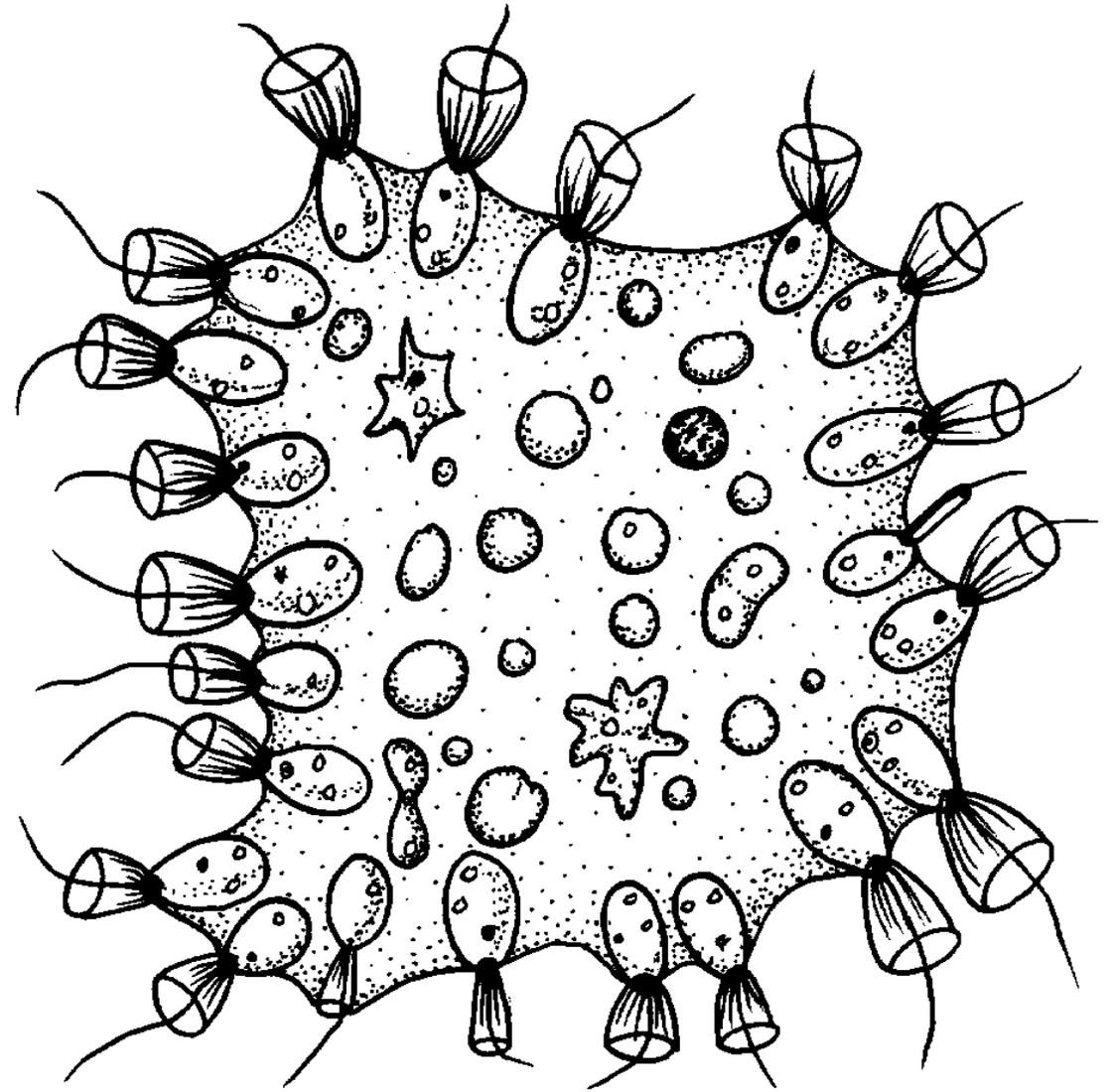
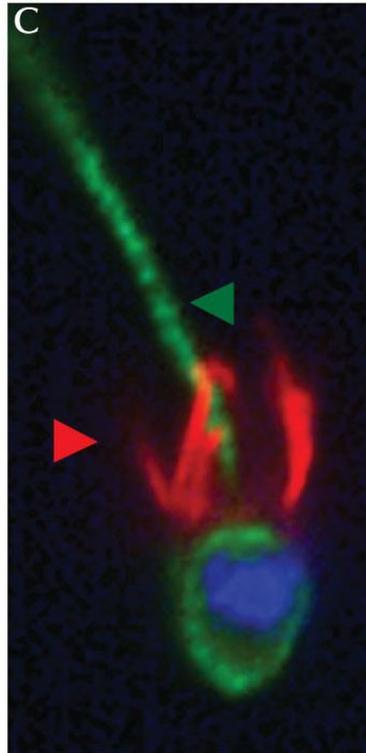
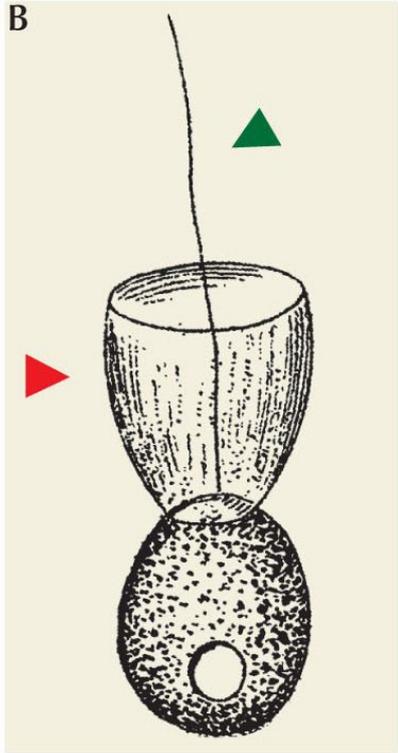
Micrasterias



Diatoms

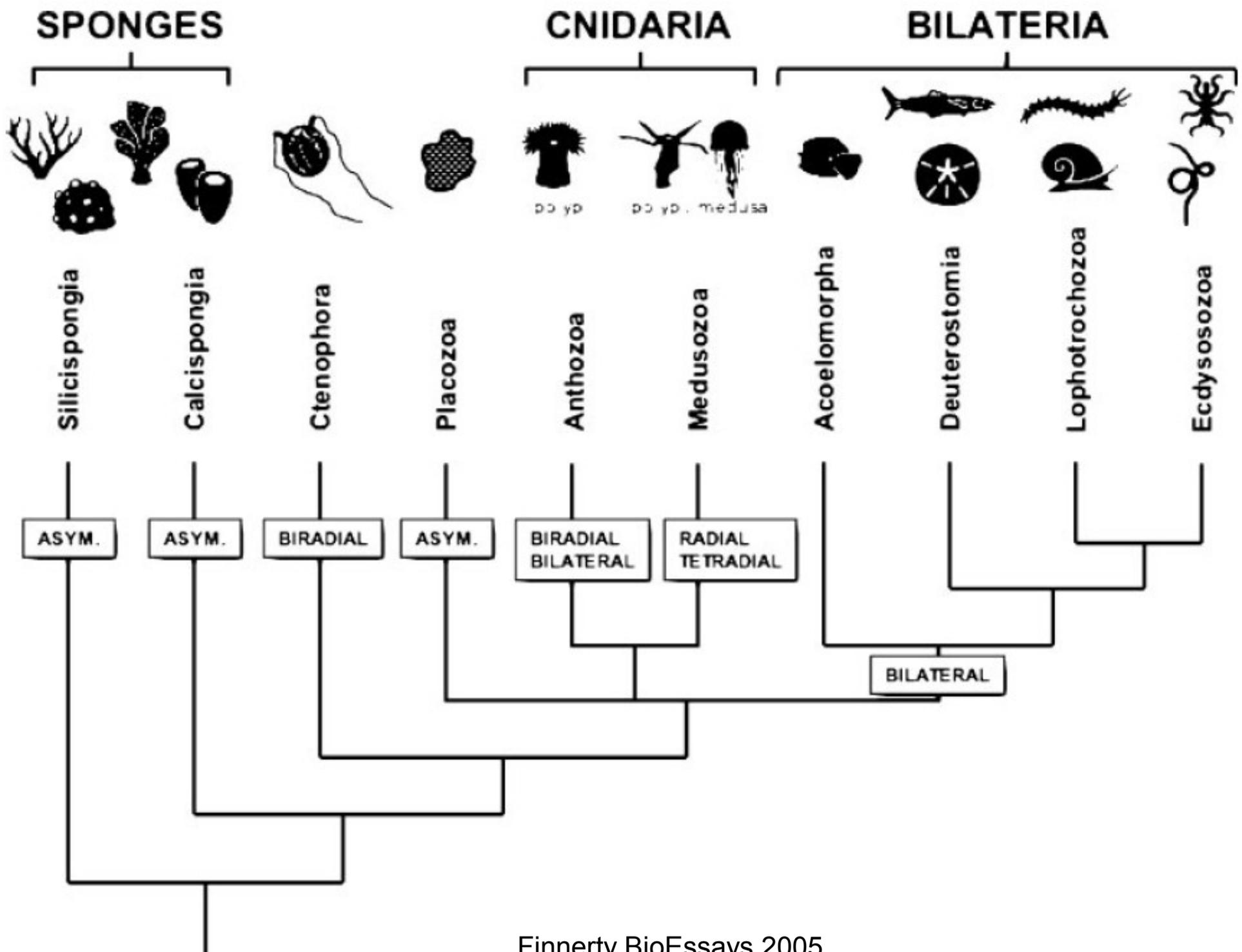


From unicellularity to multicellularity : towards a new kind of symmetry



Choanoflagellates

9/4/95

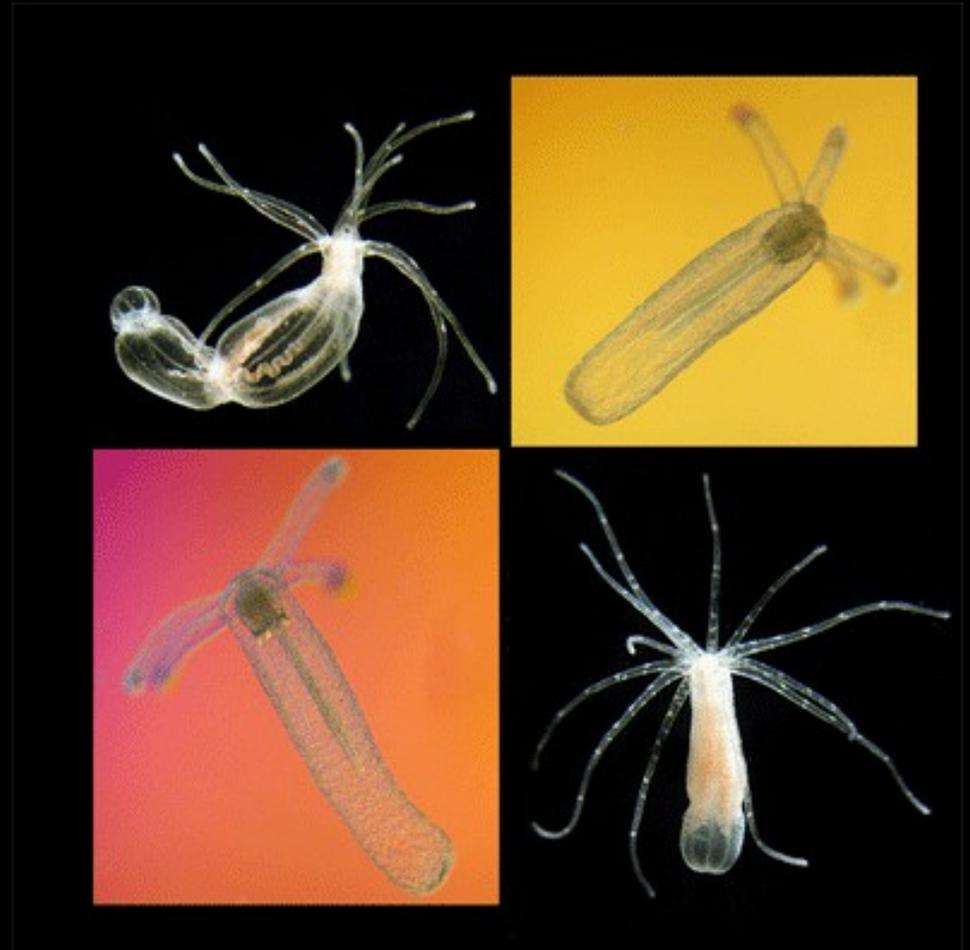


Origin of bilateral symmetry?

Cambrian explosion 500 MA

Adaptation to locomotion or digestive tract??

Anthozoan *Nematostella*



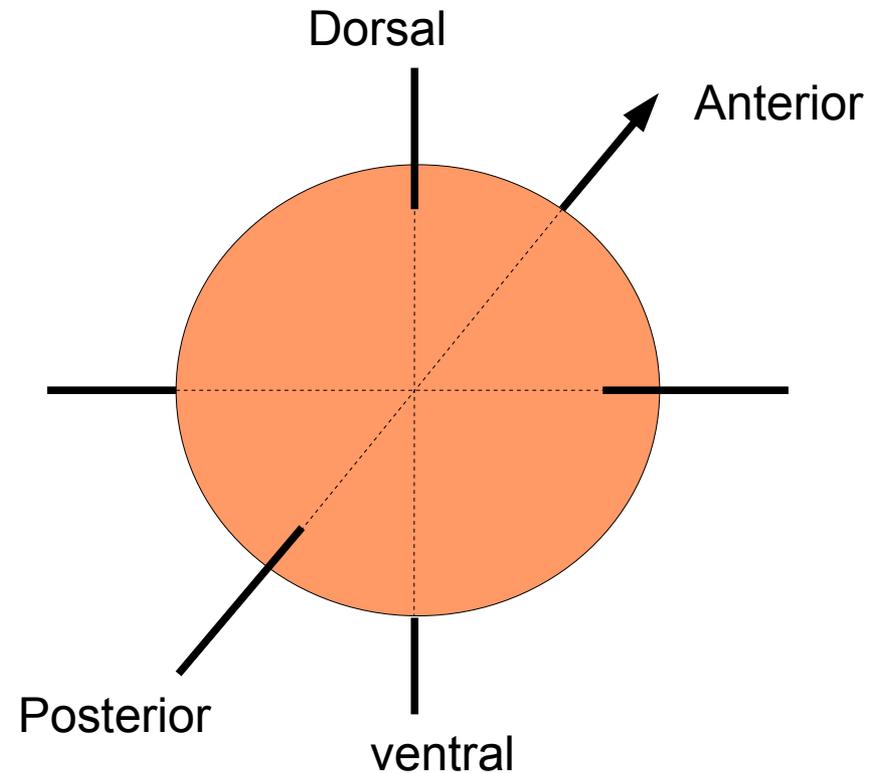
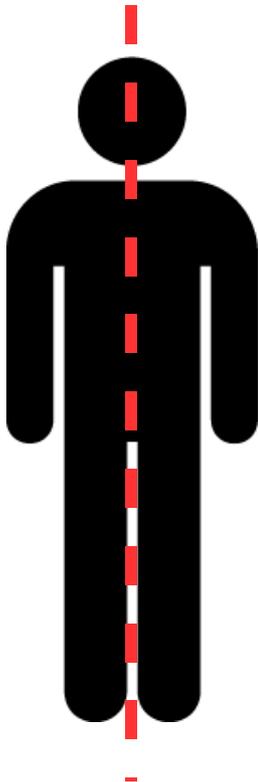
1- Bilateral (a)symmetry : developmental aspects

Development of a bilaterally symmetrical animal

Very easy :

Gravity => Dorso ventral axis

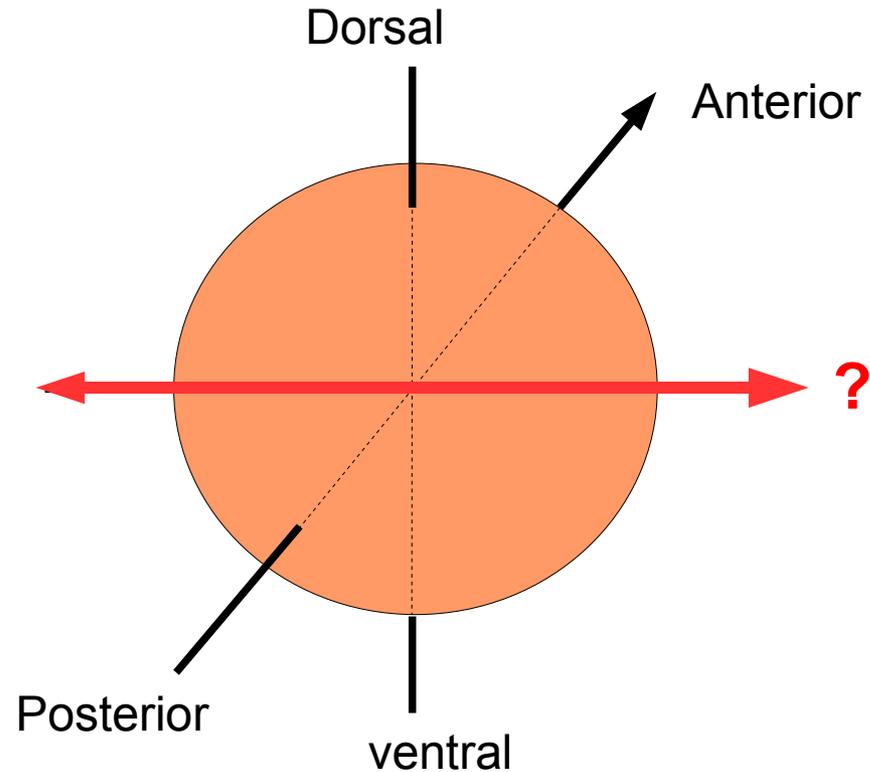
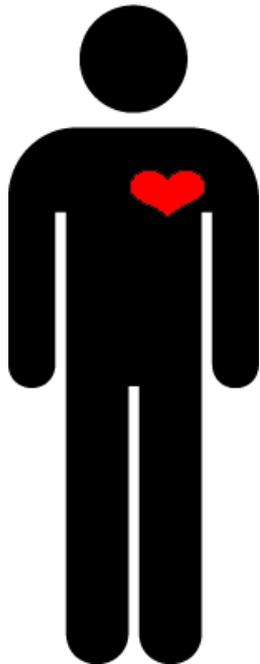
Locomotion (or other directional function) => Antero-posterior axis



Development of a bilaterally asymmetrical animal

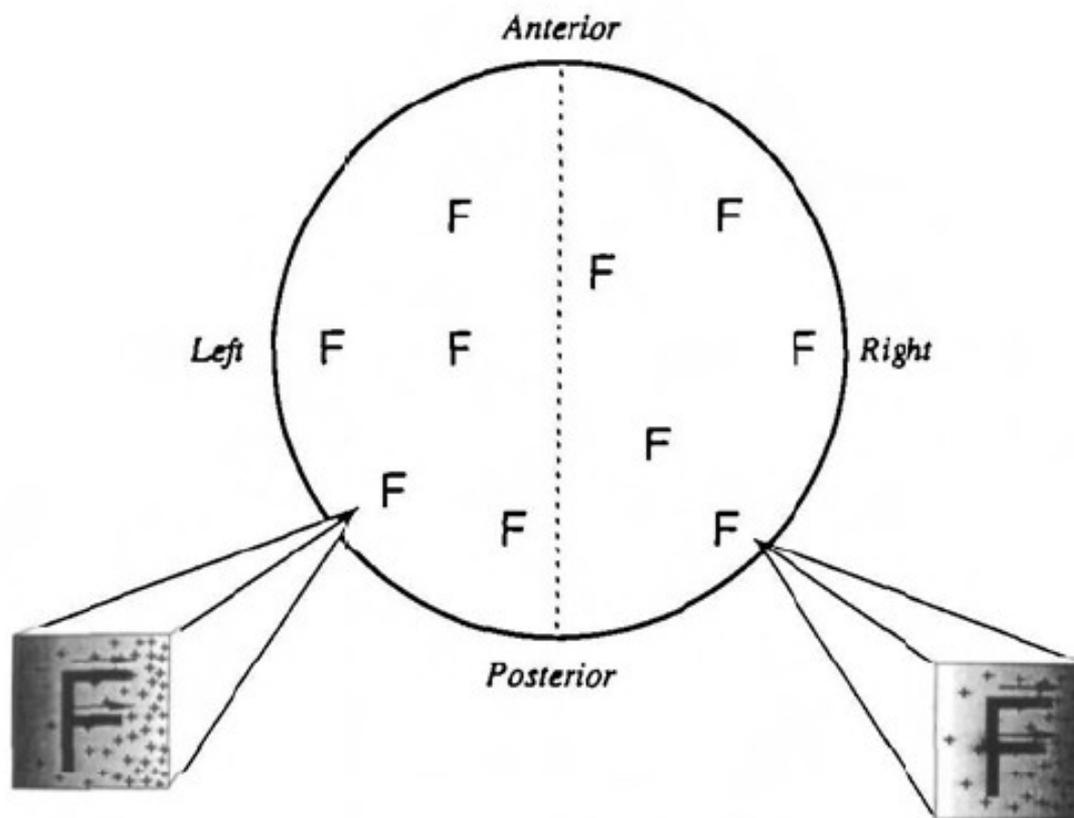
But... we are not really symmetrical!

No macroscopic reference to define right and left!



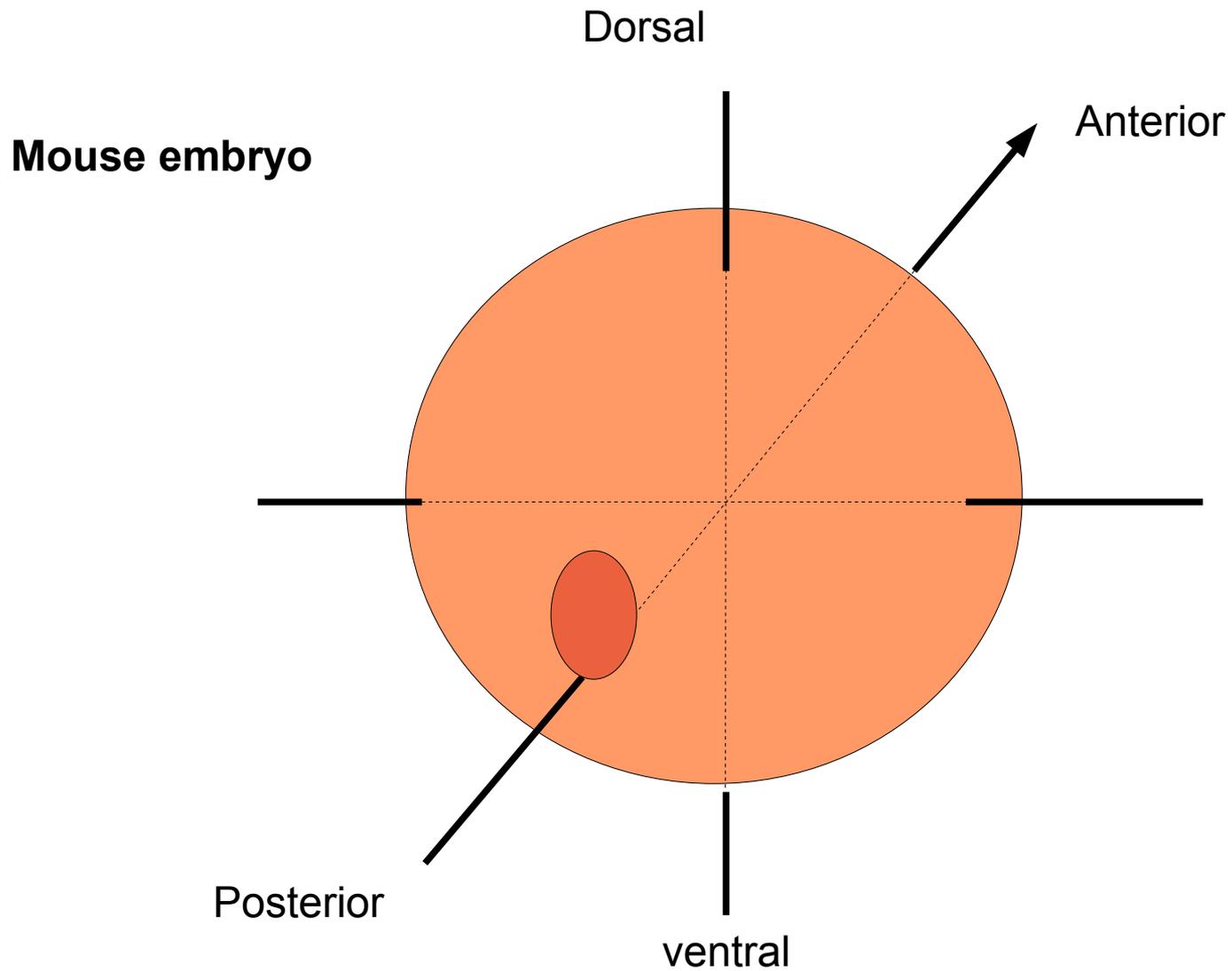
What is the first event defining orientation?

Idea of the existence of a chiral molecule ('F molecule')



What is the first event defining orientation?

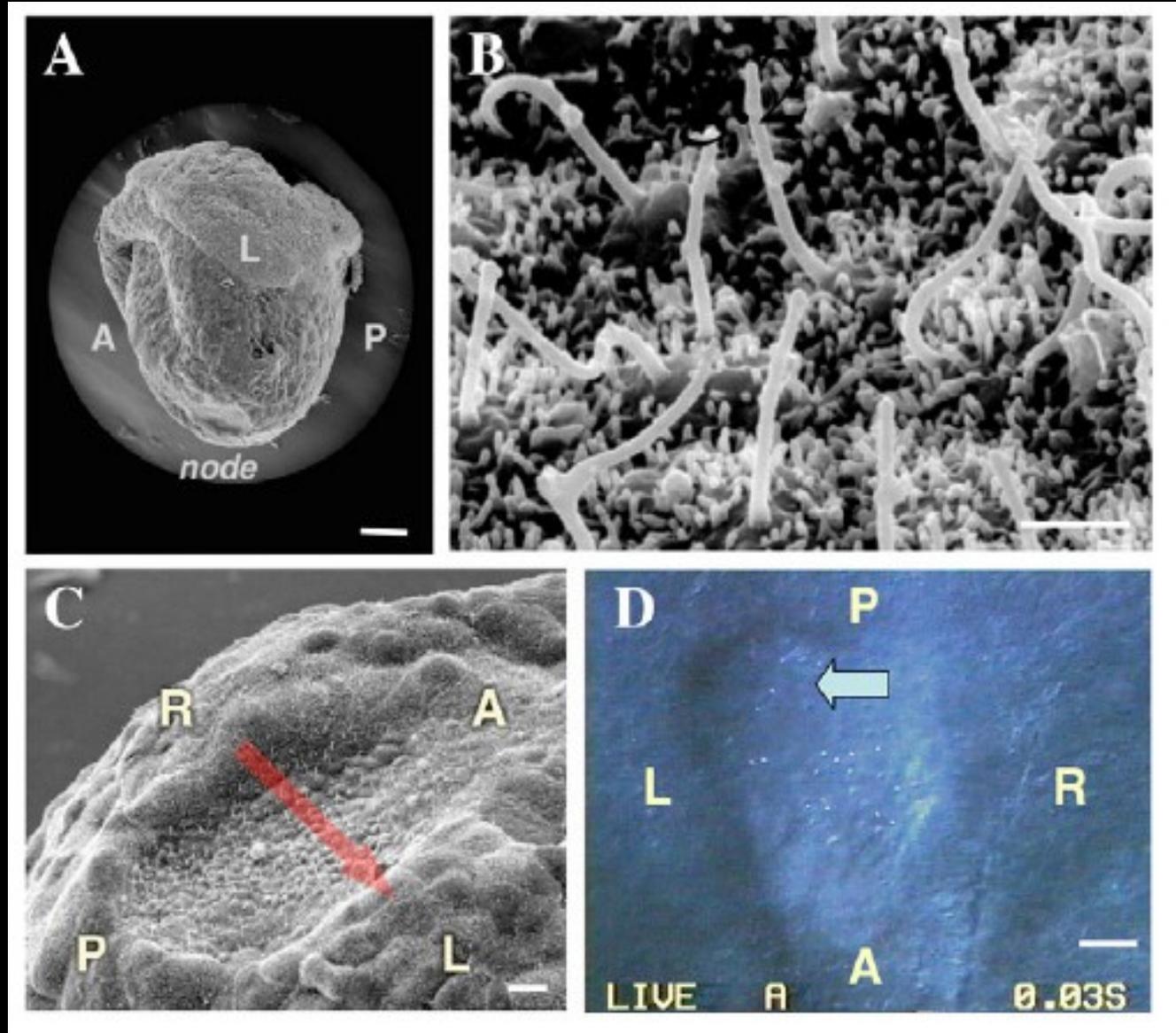
Idea of the existence of a chiral molecule ('F molecule')



What is the first event defining orientation?

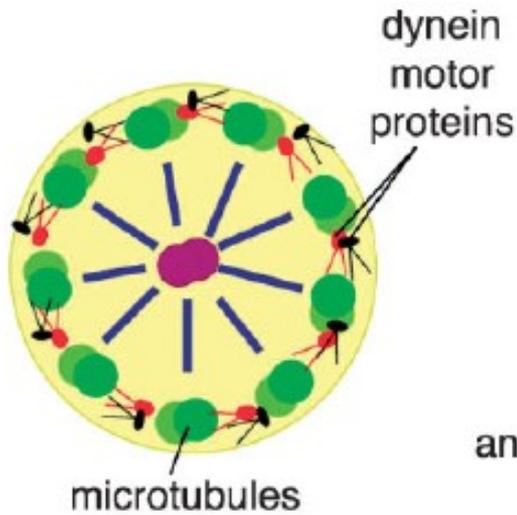
Idea of the existence of a chiral molecule ('F molecule')

Mouse embryo

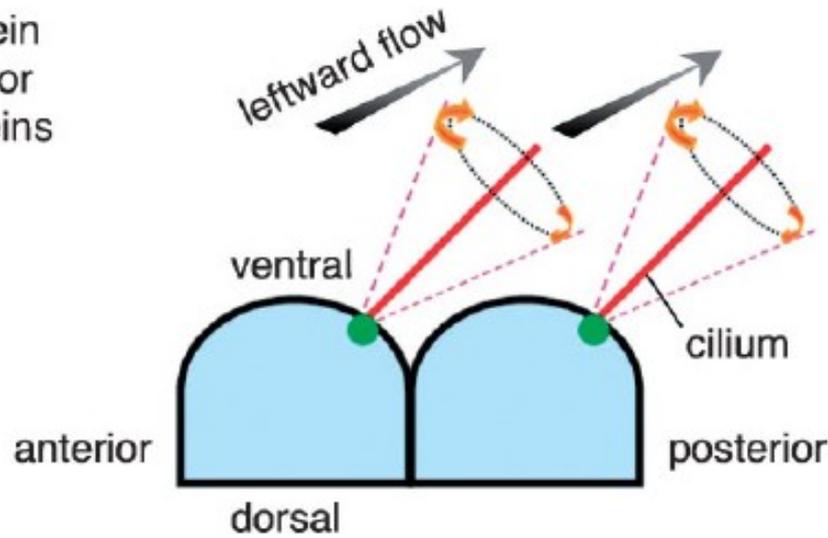


What is the first event defining orientation?

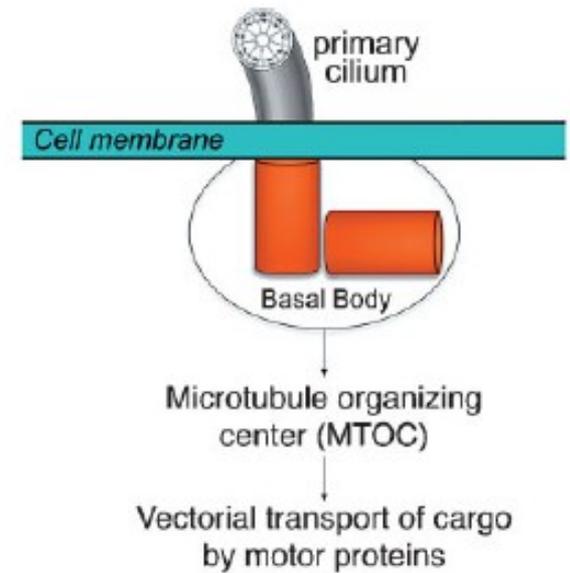
Idea of the existence of a chiral molecule ('F molecule')



A cilium internal structure



B cilia tilt & beating



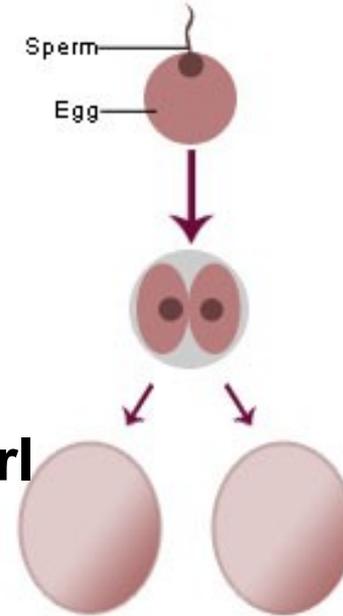
C cilia-cytoskeleton connection

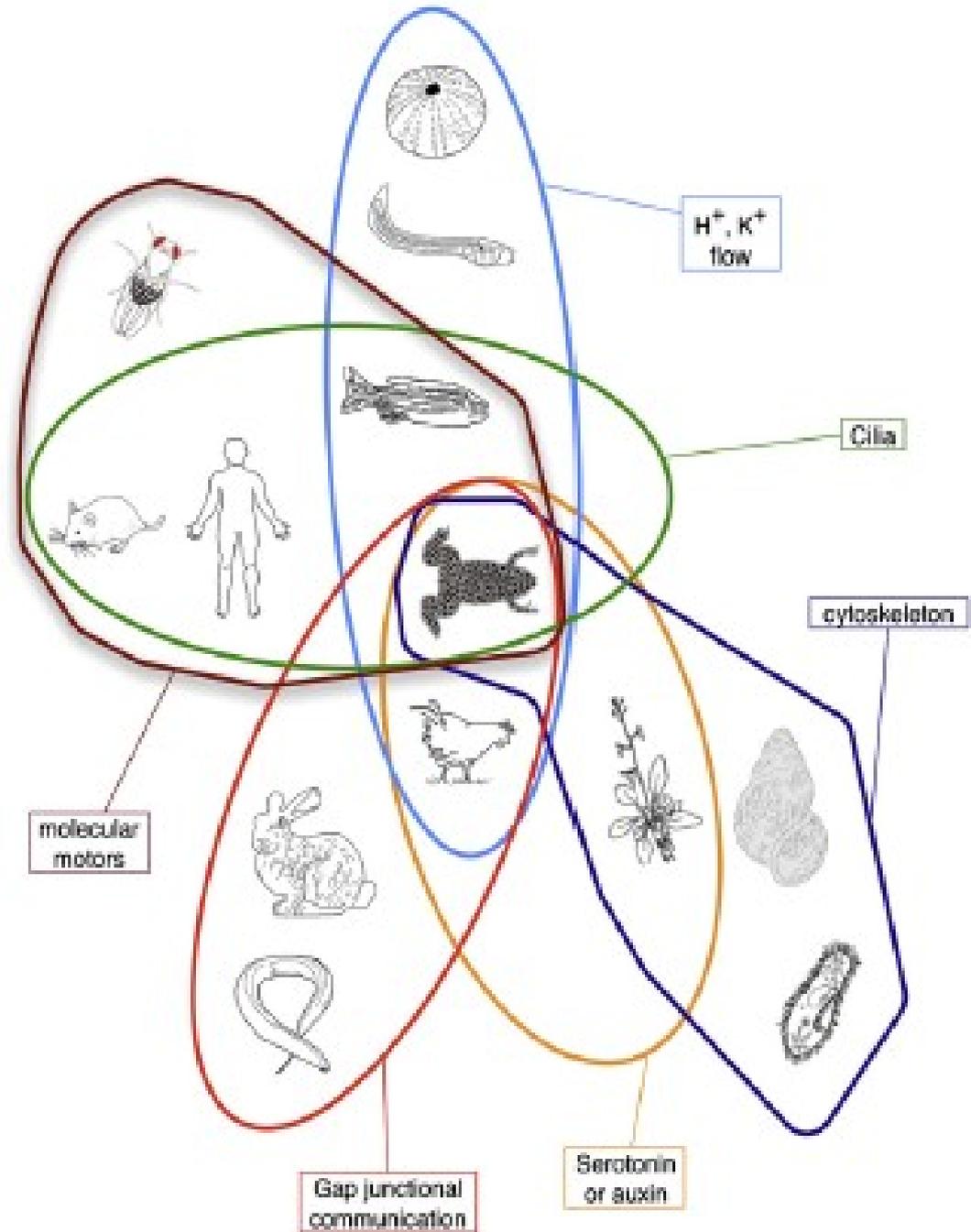
This cilia hypothesis is discussed!

**Asymmetry is defined very early
(first cell cleavage):**

Monozygotic twins have opposite hair whorl

Identical (Monozygotic) Twins





2- What can asymmetry tell us about evolution?

Before Darwin

Diversity of life was due to God
No evolution (fixism of Cuvier)

Transformism (Buffon, Lamarck)
anthropocentrism: man is the goal of evolution

Directionality = teleology



Before Darwin

Man the seed, woman the incubator

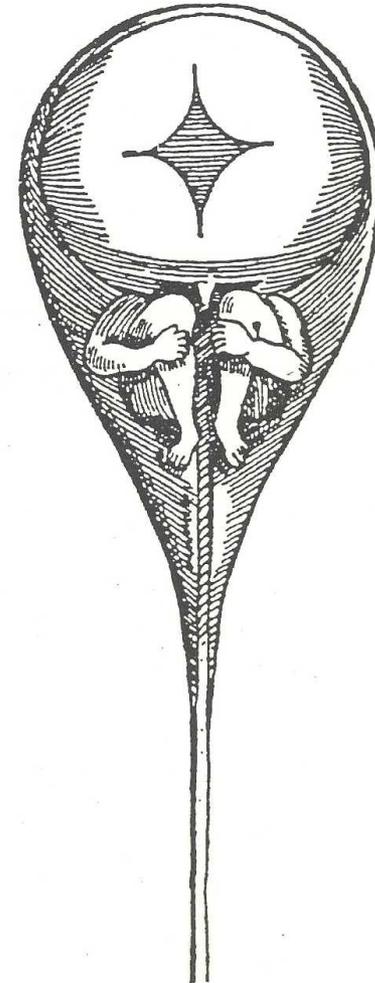
17

Developpement (french) = **Entwicklung**
(german) = **desarollo** (spanish) = **unfolding**

First microscope : sperm => homunculus

Directionality

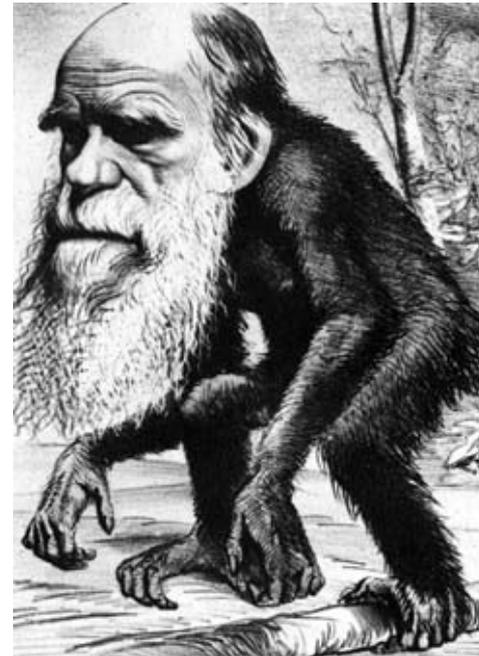
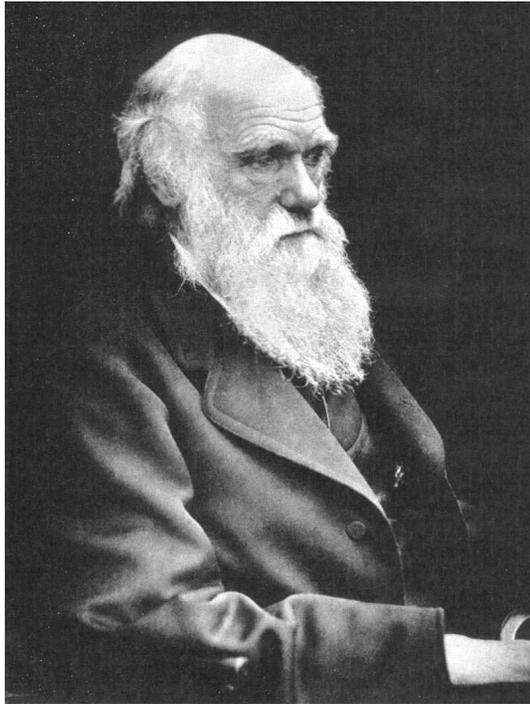
Funny and naive?



Homunculus

The little pre-formed person in the sperm. An imaginary representation of what a sperm might look like, if able to be seen clearly, drawn by Nicolaus Hartsoecker in *Essai de diotropique*, 1694.

Charles Darwin 1809 - 1882

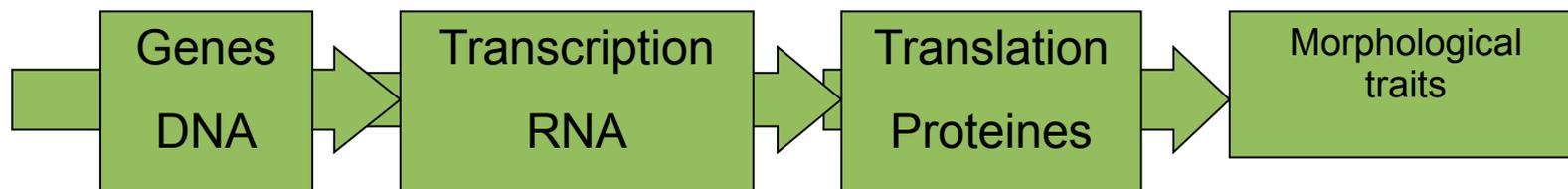


Random variation
Natural selection
Adaptation

No directionality

- 1900 rediscovery of Mendel's law of heredity (1865)
- Evolutionary synthesis (40's) = integrating genetics to darwinian theory
- 1953 Discovery of DNA structure
- 1963 Discovery of the genetic code

Molecular biology dogma: Back to teleology (directionality)



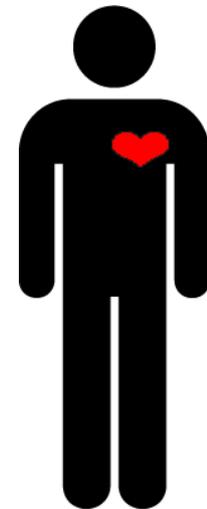
**Evolution: everything is in the genes.
Mutations lead, morphology follows**

Back to asymmetry

Two kinds of bilateral asymmetries: Fixed or Random asymmetry

Fixed asymmetry = Directional asymmetry

The direction of asymmetry is genetically fixed,
hereditary

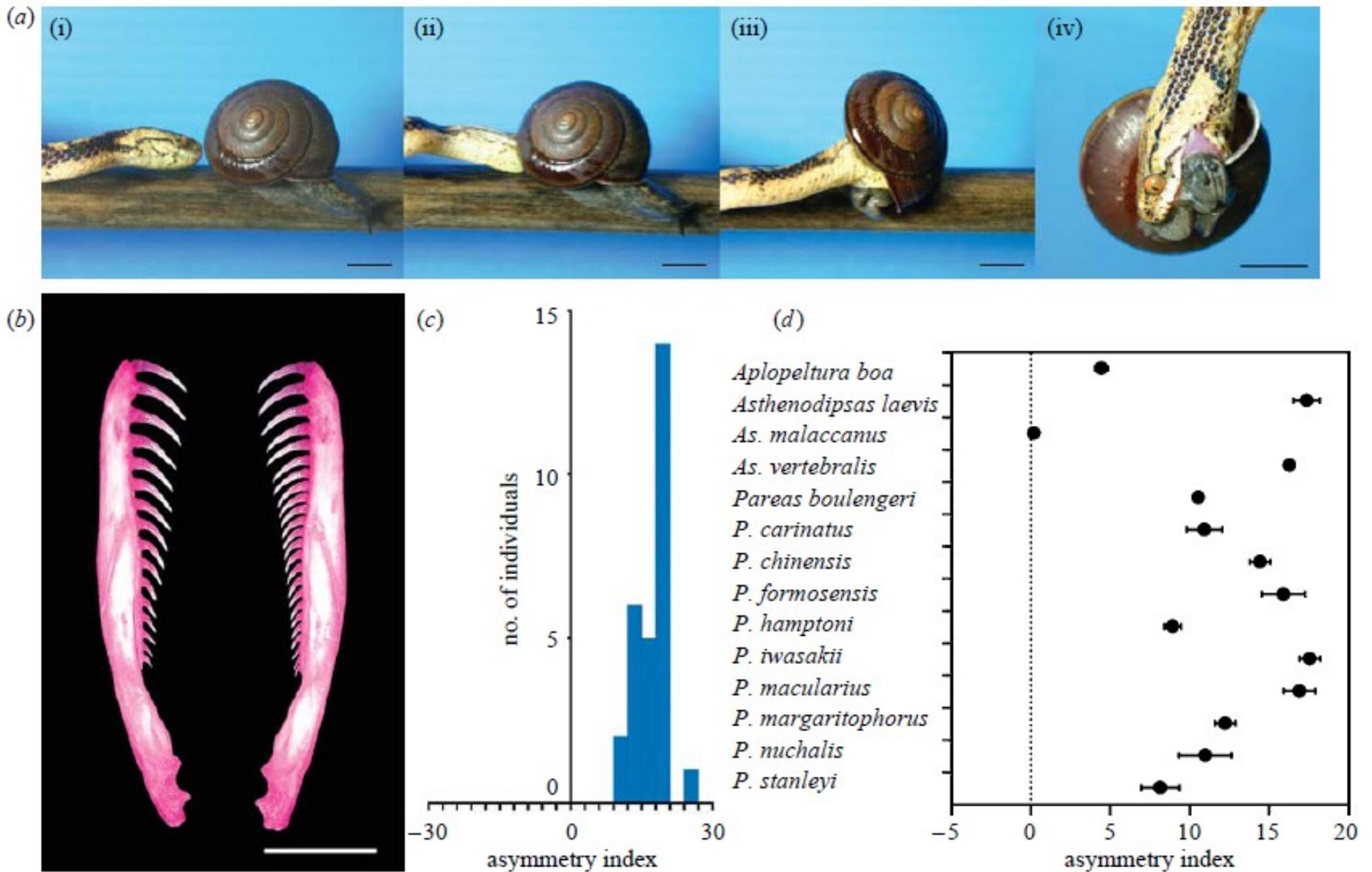


Random asymmetry = Antisymmetry

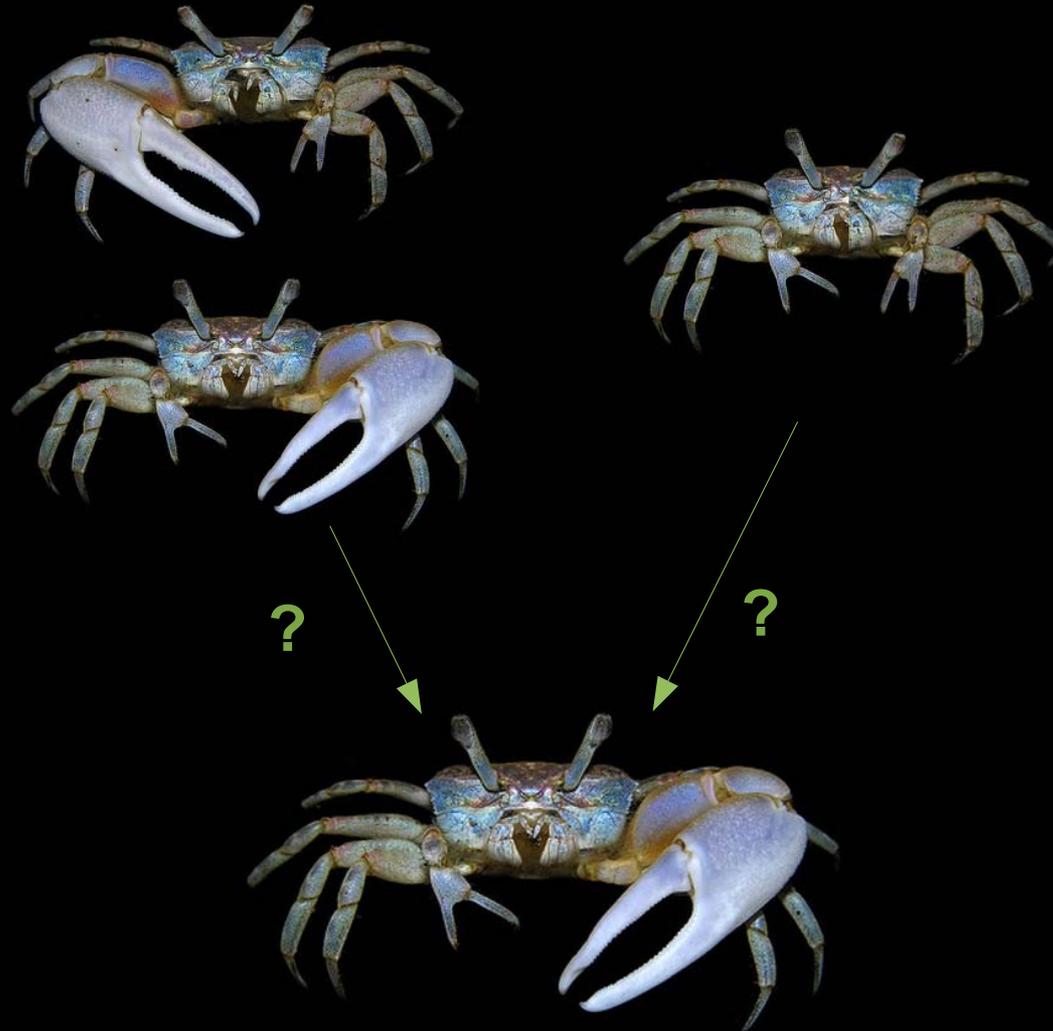
The direction of asymmetry is random and not
heritable



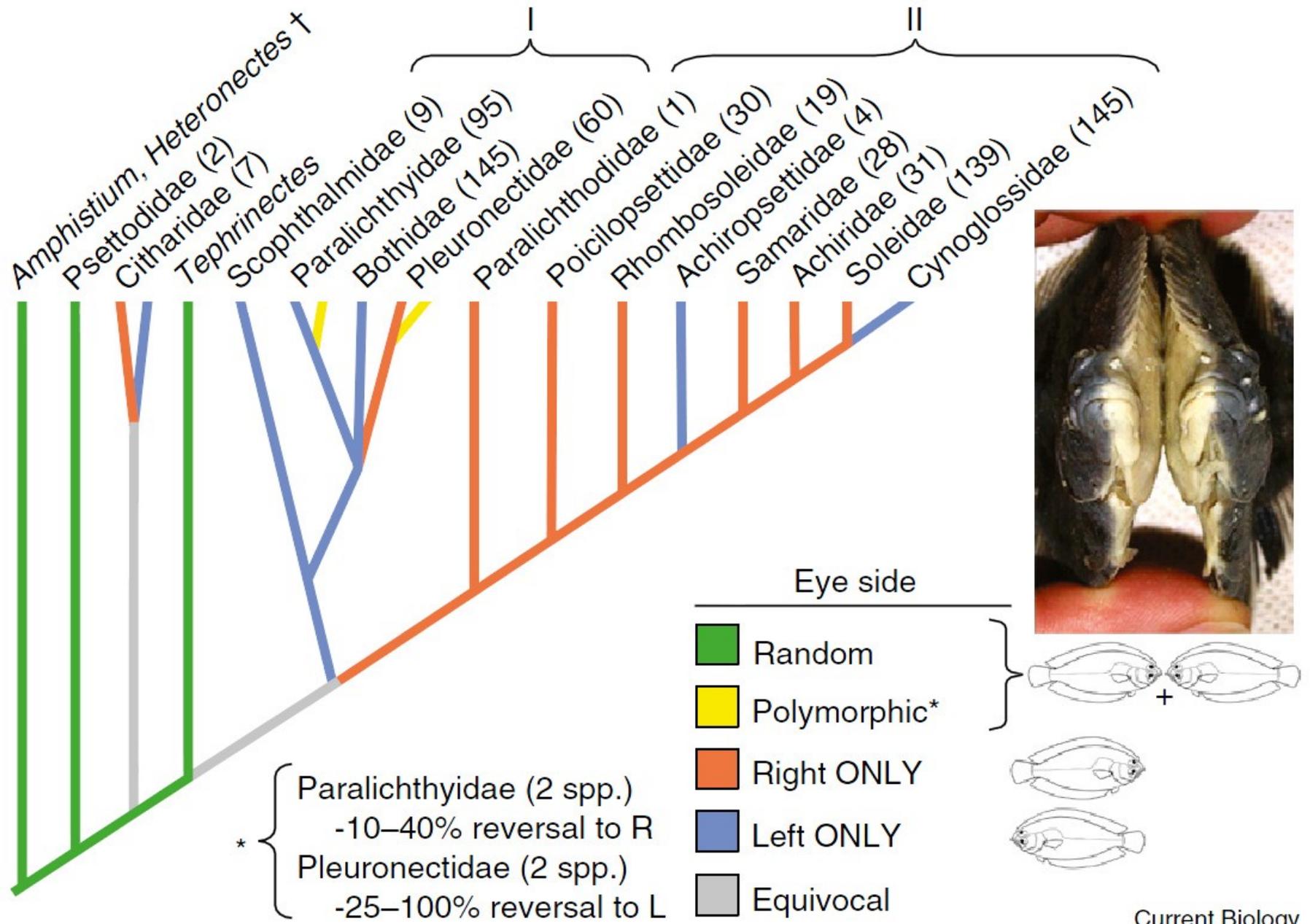
Adaptative directional asymmetry: right handed snakes

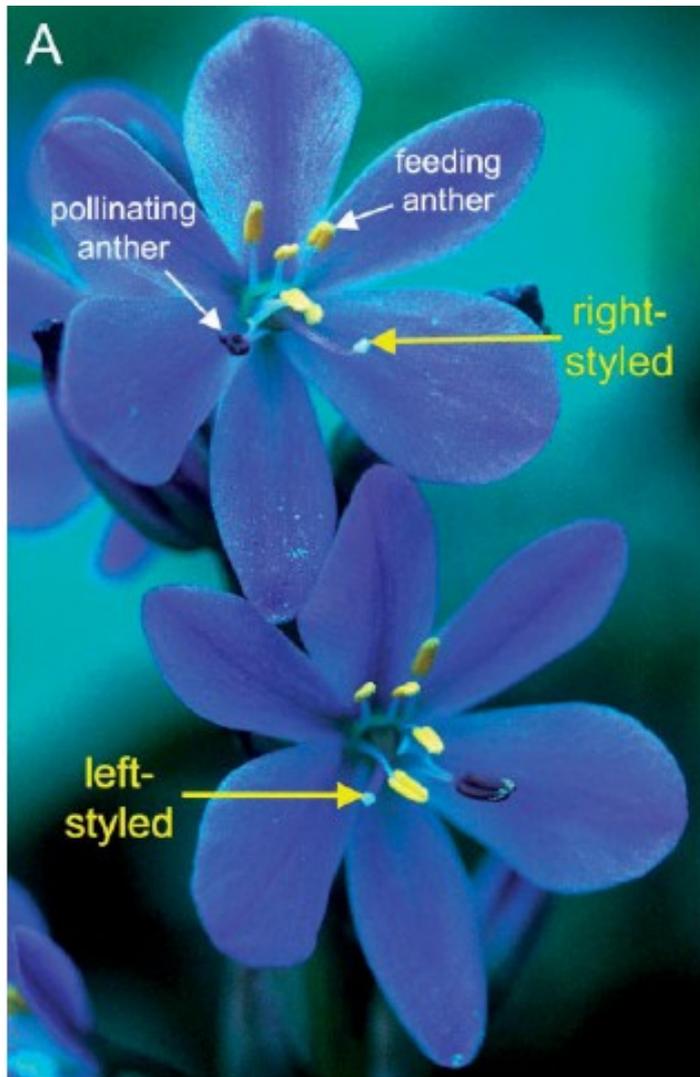


What can asymmetry tell us about evolution?



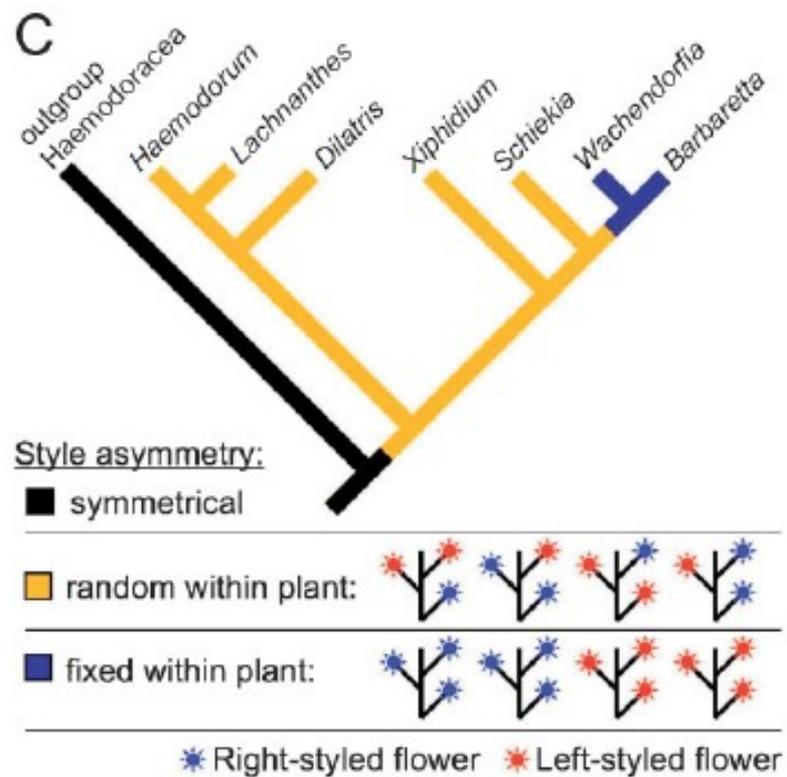
Evolution of directional asymmetry

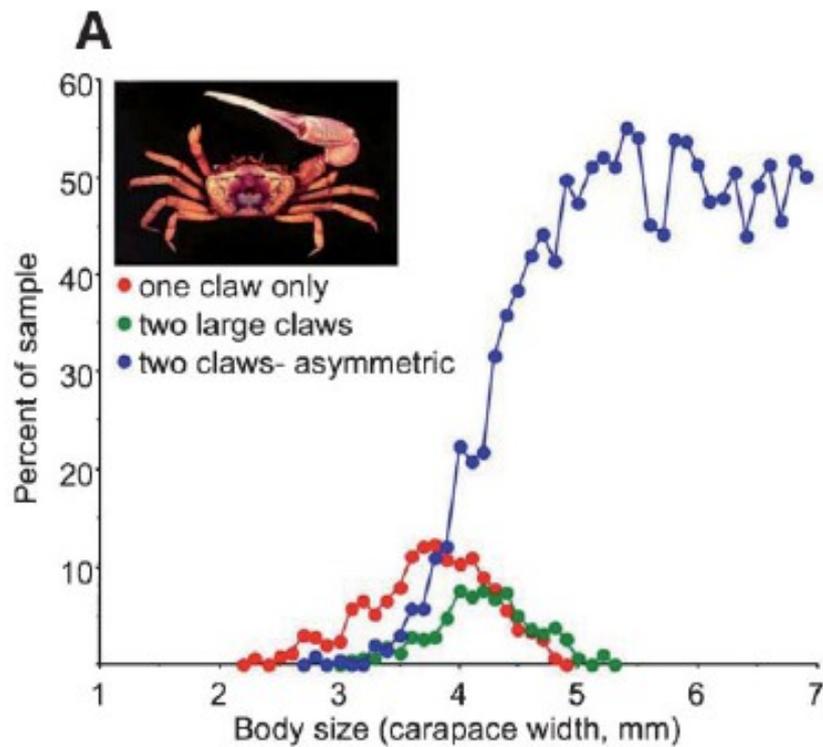




B Direction of style bend in F2

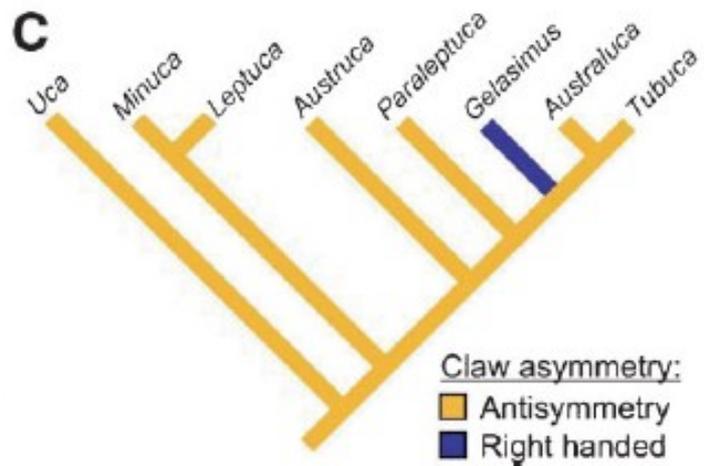
	Cross number						
	1	2	3	4	5	6	total
left	0.26	0.27	0.22	0.22	0.17	0.25	0.24
right	0.74	0.73	0.78	0.78	0.83	0.75	0.76
N	34	62	27	81	18	20	242

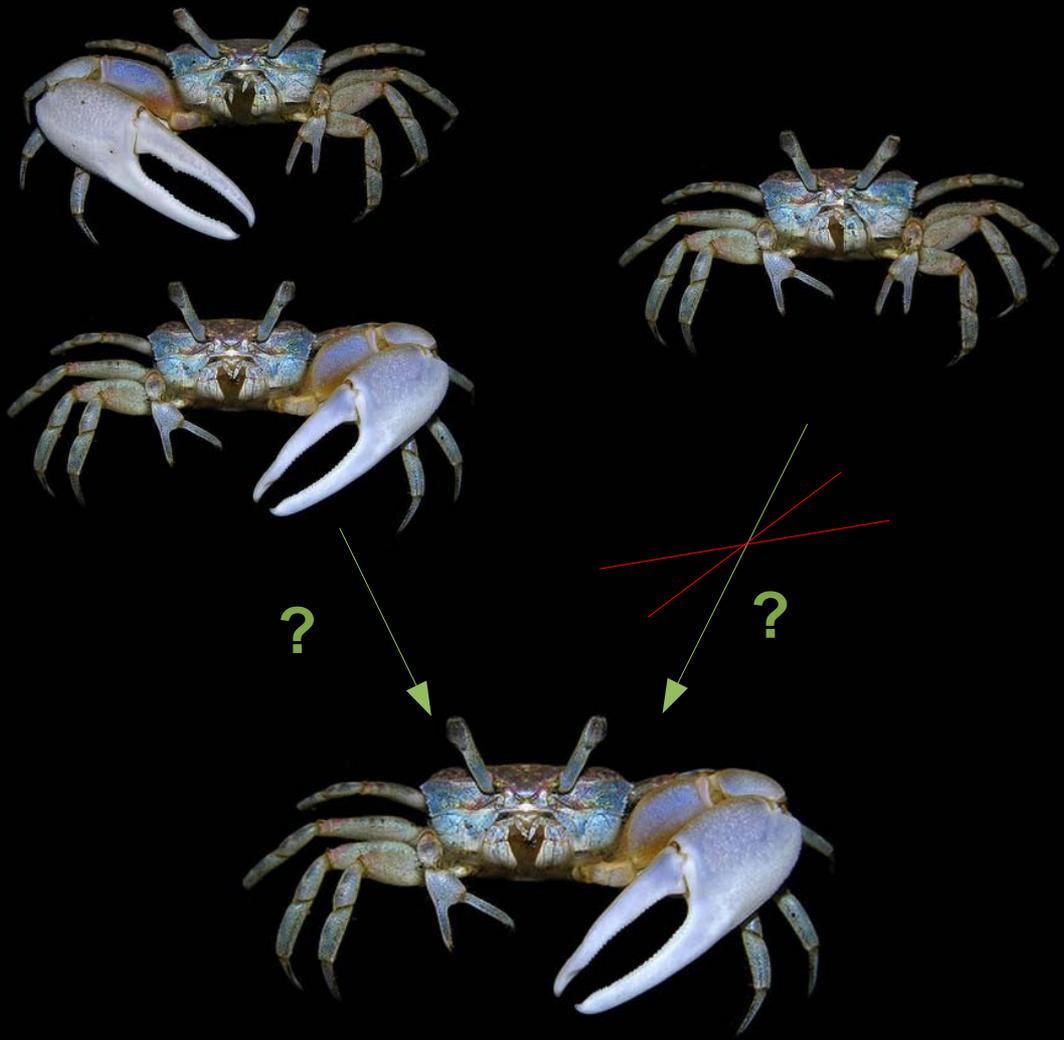




B

Treatment	Body size when claw was removed	Final side of large claw		
		Left	Right	Neither
Right cheliped removed	megalopa	33	0	0
	1.3 - 2.9 mm	284	0	0
	3.0 - 4.5 mm	72	1	1





Conclusion:

The random to fixed asymmetry occurs in about 40% of cases

Genetic assimilation, cases where phenotype leads and gene follow, might not be so rare!

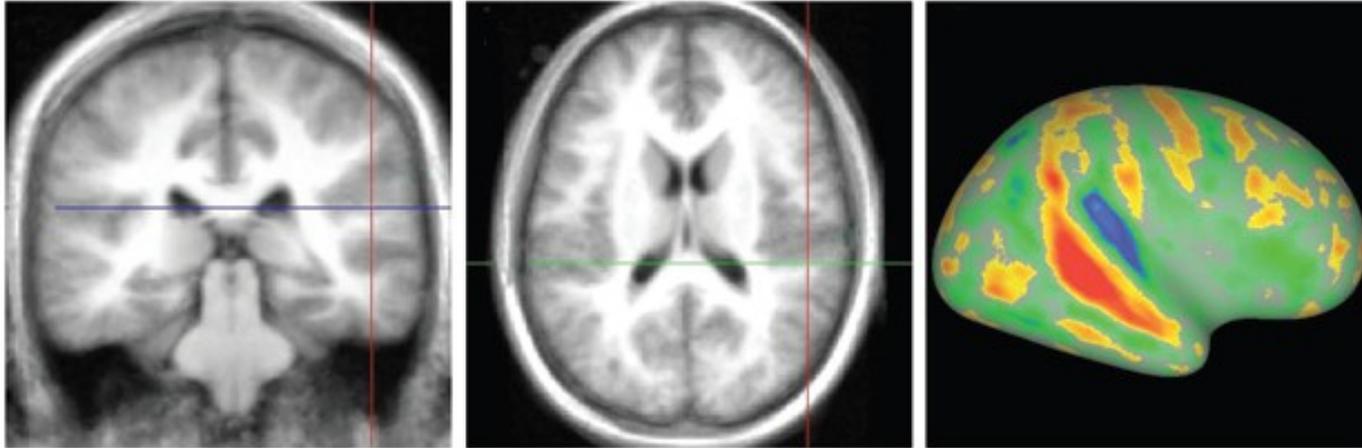
Genetic reductionism put in perspective

All is not in the genes

Darwin is conformed by a view that accounts for life true complexity

3 - Asymmetry and the social sciences

Asymmetry in the social sciences



Sun and Walsh 2006

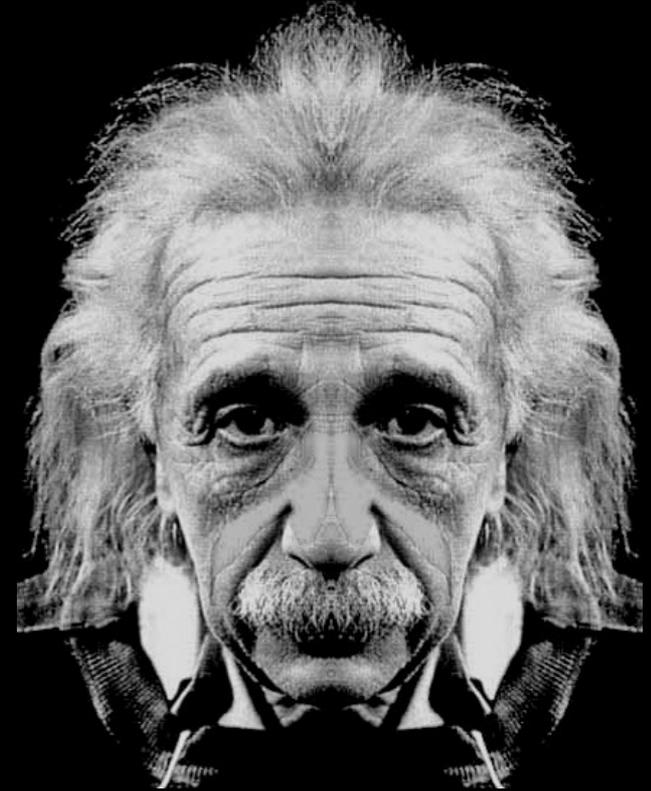
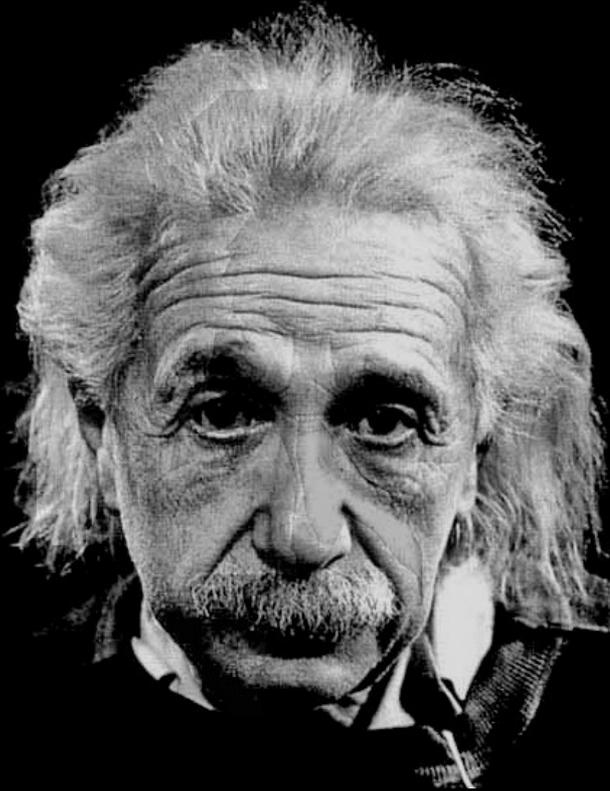
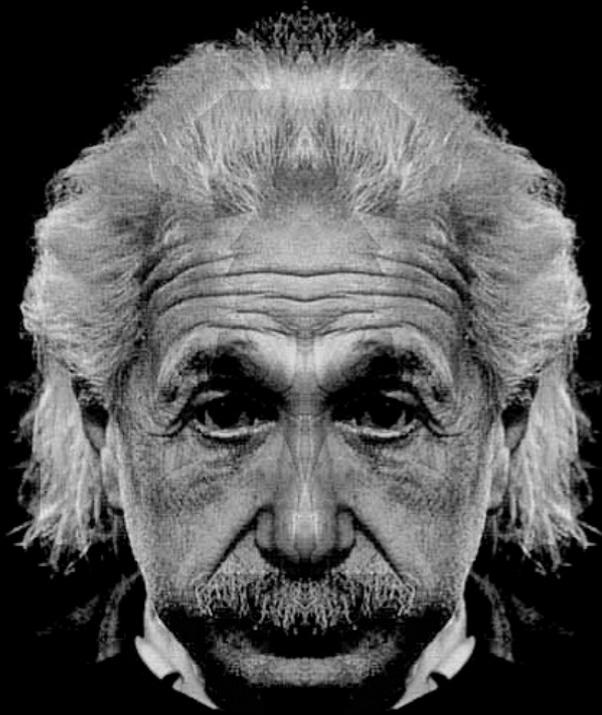
Laterality

Faurie et Raymond (2004): proportion of left handed vs right handed did not change for the last 10 000 years

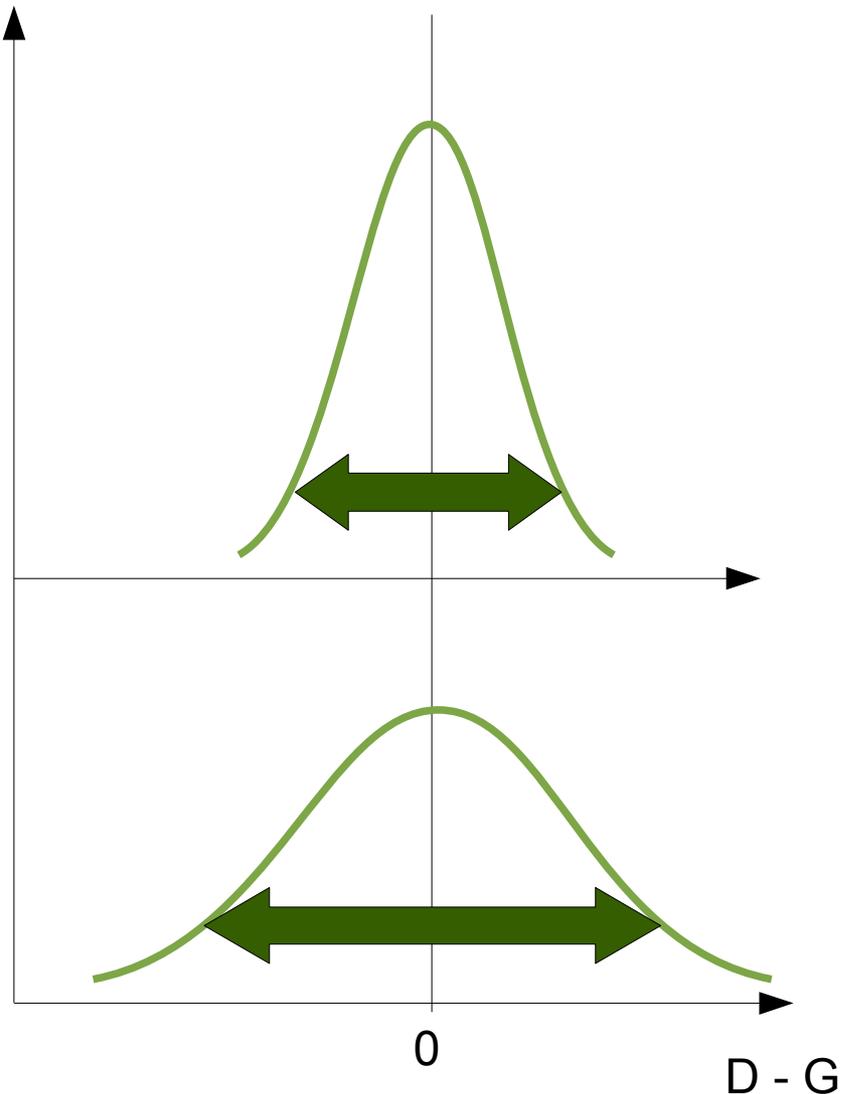


Fluctuating asymmetry

= small departure from perfect bilateral symmetry



Fluctuating asymmetry = variance of the right - left distribution



This asymmetry can be dramatically different among populations

Stressful genetic or environmental conditions can increase FA

Interesting for conservation biology

Fluctuating asymmetry, stress and fitness : « symmetry is beauty »?



Photo courtesy N. Gompel

The idea:

good genes => stable development => symmetry

In turn: poor symmetry => bad genes

Sexual selection : Fittest males are the most symmetrical = 'good genes hypothesis'.

Females will choose symmetric males;
Males will thus display their symmetry

Major problem :

for FA to be a reliable indicator of quality, it has to be hereditary (together with the good genes it is supposed to indicate!)



Photo: Hannes Mitchell



Evolution and Human Behavior 24 (2003) 113–117

Evolution
and Human
Behavior

FA and sociobiology

Fluctuating asymmetry and romantic jealousy[☆]

William M. Brown* Chris Moore

Available online at www.sciencedirect.com



Intelligence 35 (2007) 41–46



Fluctuating asymmetry and intelligence

Timothy C. Bates *

Anim. Behav., 1995, **50**, 1601–1615

Human female orgasm and mate fluctuating asymmetry

Arch Sex Behav (2008) 37:150–157
DOI 10.1007/s10508-007-9256-2

ORIGINAL PAPER: MINOT SPECIAL ISSUE

& RANDALL COMER†
Mexico
Mexico

January 1995;
(7105)

Fluctuating Asymmetry and Sexual Orientation in Men and Women

Stacie S. Miller · Heather L. Hoffmann ·
Brian S. Mustanski

FA follies

FA in breasts:

is negatively correlated with fecundity; positively with risk of breast cancer; negatively with attractiveness

FA, scent and human attractiveness:

“Results indicated that normally cycling (non-pill using) women near the peak fertility of their cycle tended to prefer the scent of shirts worn by symmetrical men.”

FA and human orgasm :

“Women with partners possessing low FA reported significantly more copulatory female orgasms than were reported by women with partners possessing high FA and their partners”

FA and IQ:

“there is a real, common, causal link between bodily asymmetry and lowered IQ. Indeed, they are prepared to estimate that anything between 17 and 50 per cent of the variability in IQ is attributable to [the causes of higher fluctuating asymmetry].”



**SYMMETRY SUCKS.
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design by nissan

Thank you for your attention

Laterality, hand clasping and arm folding

