

# Communicating biological complexity

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# Biology and folkbiology

- Genetic, epigenetic and exogenetic information interact to produce flexible implementations of complex life history strategies
- Public understanding of this complexity is obstructed by an ancient, implicit model in which traits are either expressions of an inherited 'nature' or imposed by the environment



Animal natures reassert themselves on the island of Dr Moreau

# Senses of 'Epigenetic'

- Epigenesis: the idea that the outcomes of development are created in the process of development, not preformed in the inputs to development; 'epigenetic' can be used in this sense (e.g. Harvey 1650)
- Epigenetics (broad sense – Waddington 1942): the study of the causal mechanisms by which genotypes give rise to phenotypes; the integration of the effects of individual genes in development to produce the 'epigenotype'
- Epigenetics (narrow sense – Nanney 1958): the study of the mechanisms that determine which genome sequences will be expressed in the cell; the control of cell differentiation and of mitotically and sometimes meiotically heritable cell identity
- Epigenetic inheritance (narrow sense): the inheritance of genome expression patterns across generations (e.g. through meiosis) in the absence of a continuing stimulus
- Epigenetic inheritance (broad sense): the inheritance of phenotypic features via causal pathways other than the inheritance of nuclear DNA - 'exogenetic inheritance' (West and King 1987)

Griffiths and Stotz *Philosophy and Genetics* 2013

# Developmental systems

“An animal is, in fact, a developmental system, and it is these systems, not the mere static adult forms which we conventionally take as typical of the species, which become modified in the course of evolution”

Conrad H. Waddington, Conrad H. “The Evolution of Developmental Systems.” *Australian and New Zealand Association for the Advancement of Science*, 1952, 155.



# The Nature of the Beast

- 'Innate', 'instinctive', 'human nature' are expressions of a folkbiological (implicit) theory of animal natures
- Animal natures are transmitted from parent to offspring
- Some traits of individuals are expressions of this inner nature, others are imposed by the environment

Griffiths, Paul E, Edouard Machery, and Stefan Linquist. "The Vernacular Concept of Innateness." *Mind and Language* 24, no. 5 (2009): 605-30.

Linquist, Stefan, Edouard Machery, Paul E Griffiths, and Karola Stotz. "Exploring the Folkbiological Conception of Human Nature." *Philosophical Transactions of the Royal Society B* 366 (2011): 444-53.



# The three-factor model

- Developmental fixity
  - 'hard to change': insensitive to environmental inputs in development; development appears goal-directed (resistant to perturbation)
- Species typicality
- Teleology

# The three-factor model

- Developmental fixity
- Species typicality
  - part of what it is to be an organism *of that kind*, with consequent associations of typicality or universality
- Teleology

# The three-factor model

- Developmental fixity
- Species typicality
- Teleology
  - how the organism is *meant* to develop; to lack the innate traits is to be malformed; environments that disrupt their development are unnatural ('bad rearing')



# Testing the three-feature model

	Typical	~Typical
Fixed	Teleology	Teleology
	~Teleology	~Teleology
~Fixed	Teleology	Teleology
	~Teleology	~Teleology

# Sample probe



Birdsong is one of the most intensively studied aspects of animal behaviour. Since the 1950s scientists have used recordings and acoustic analysis to uncover the structure and function of birdsong. Neuroscientists have investigated in great detail the areas of the brain that allow birds to develop and produce their songs and hormonal influences on song production. Other scientists have done ecological fieldwork to study what role song plays in the lives of different birds.

Archer's Grasshopper Warbler (*Locustella virens*) is a mid-sized, greenish-brown grass warbler which breeds from western Siberia east to Japan and Korea. It is migratory, wintering in southeast Asia. It can be shown by experimentally manipulating what young birds hear that the sequence of song elements produced by an adult Archer's Grasshopper Warbler male depends on which sequences it hears when it is young. Furthermore, studies have shown that there is no significant inter-population and inter-individual variation in the sequence of song elements produced by Archer's Grasshopper Warbler males. Finally, close observations of these birds reveal that the sequence of song elements produced by Archer's Grasshopper Warbler males does not help them attract mates and does not help them to defend their territory. Scientists therefore agree that the sequence of song elements produced by Archer's Grasshopper Warbler males is not an adaptation

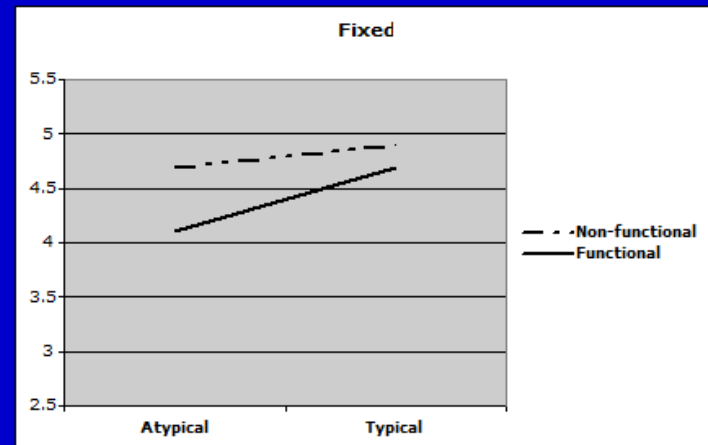
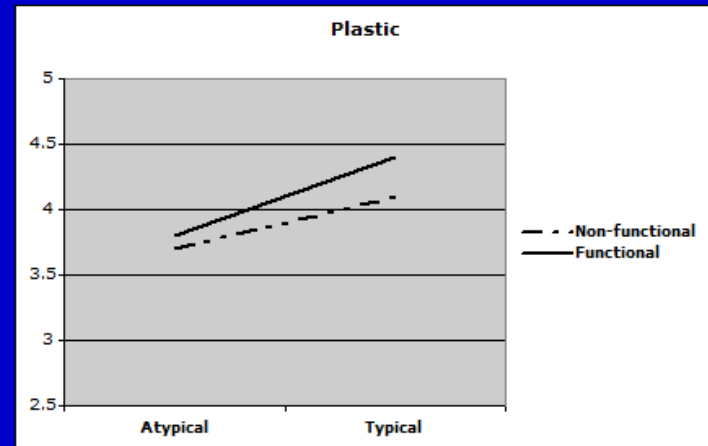
On a 7-point scale, 1 meaning strongly disagree and 7 meaning strongly agree, how would you respond to the following statement?

"The sequence of song elements produced by a male Archer's Grasshopper Warbler is..."

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

# “The sequence of song elements produced by a male <bird name> is innate.”

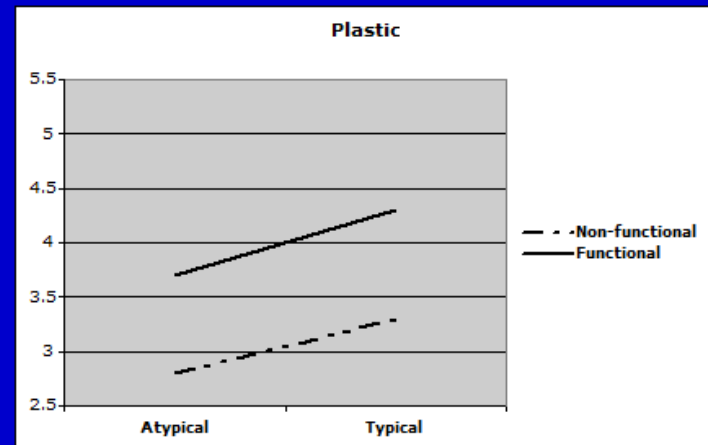
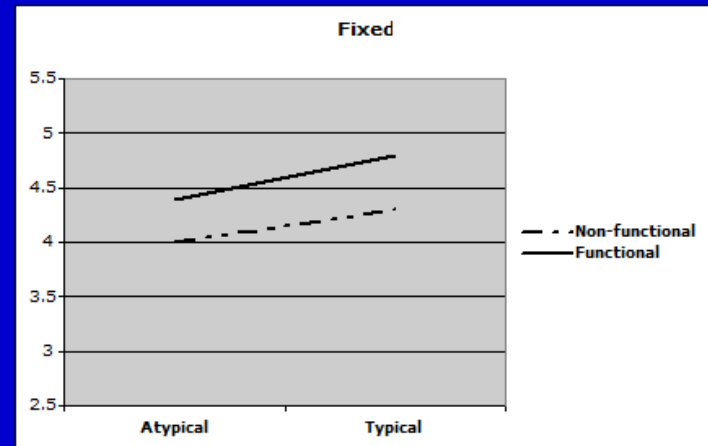
- 97 subjects
- 16% of variance
- Fixity and Typicality have significant effects
- No significant interaction



Linguist, Machery, Griffiths, and Stotz "Exploring the Folkbiological Conception of Human Nature." *Philosophical Transactions of the Royal Society B* (2011).

# “The sequence of song elements produced by a male <species name> is in it’s DNA.”

- 109 subjects
- 46% of variance
- All three factors have a substantial and significant effect
- No significant interaction



Linguist, Machery, Griffiths, and Stotz "Exploring the Folkbiological Conception of Human Nature." *Philosophical Transactions of the Royal Society B* (2011 ).

# Dar-Nimrod's 'genetic essentialist biases'

Genetic Essentialist Elements (Dar-Nimrod and Heine 2011a)	Three-factor model of 'animal natures' (Linguist et al. 2011)
<b>Immutable and determined:</b> thinking about genetic attributions leads people to view relevant phenotypes as less changeable and predetermined	<b>Fixity:</b> phenotypes that do not depend on the particular environment in which the organism is raised
<b>Specific etiology:</b> the tendency to discount additional causal explanations once genetic attributions are made	Traits are <b>either</b> expression of the animals nature (and are expected to have the three features) <b>or</b> imposed by the environment (with opposite expectations)
<b>Homologous and discrete:</b> focus on features common to all group members, drawing attention away from in-group differentiating features	<b>Typicality:</b> phenotypes that are typical of the entire species (or some natural subset such as males or juveniles)
<b>Nature:</b> phenotypes are perceived as a natural outcome (positive normative associations)	<b>Teleology:</b> phenotypes that serve some purpose (positive normative associations)

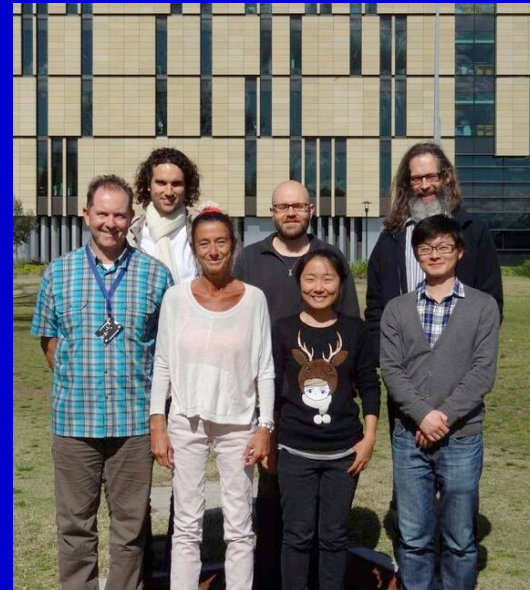
# Conclusions

- In communicating biological complexity 'audience effects' may completely drown the original scientific signal
- Effective communication involves a good model of how information is being assimilated
- Evidence-based guidelines are needed on how to communicate biology, rather than simply re-label folkbiology

# Acknowledgments

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Perkins Centre**

[www.griffithslab.org](http://www.griffithslab.org)

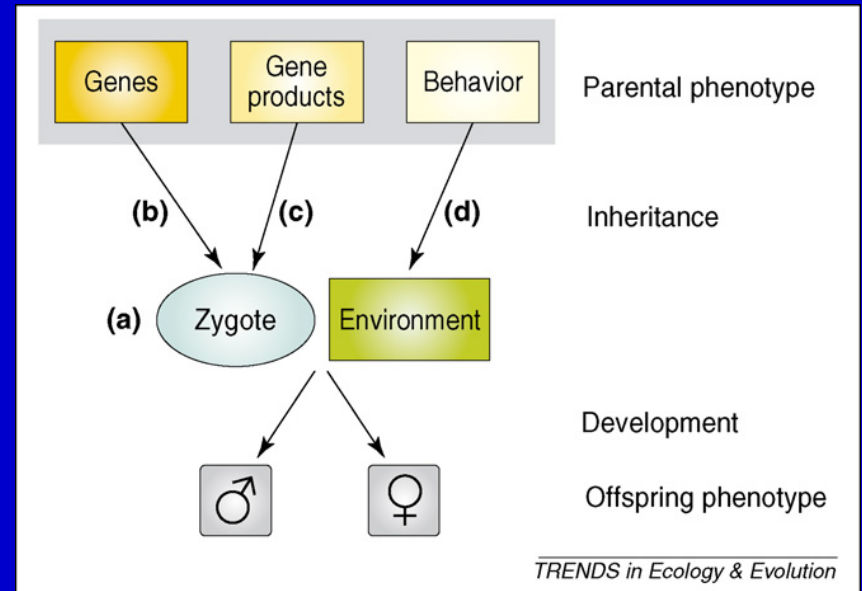






# Parental effects

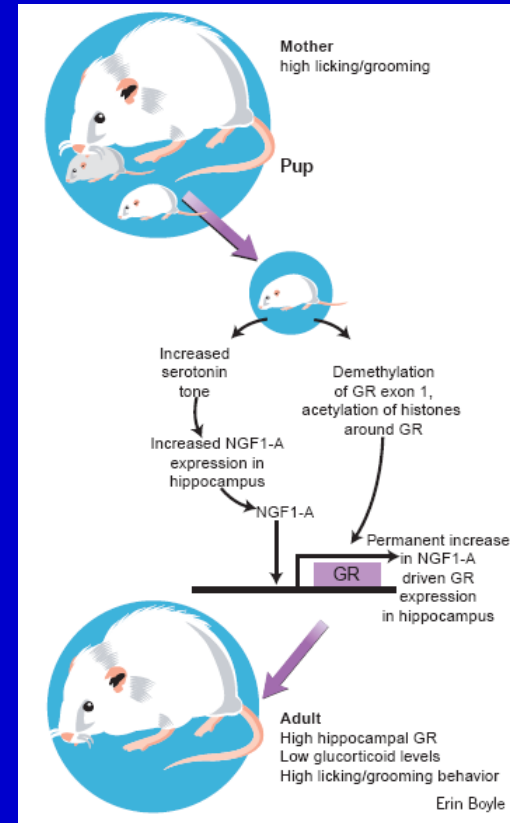
- Correlations between parent and offspring phenotype independent of correlations between parent and offspring genotype
- Parental effects on fitness must be explained by a physical mechanism of transmission (e.g. Larger seed body, gene methylation)



Uller, Pen, Wapstra, Beukeboom & Komdeur, (2007).

# Epigenetic inheritance

- *Sensu strictu* - heritable modifications of gene expression via modifications to DNA and its associated structural molecules (e.g. Methylation, histone modifications)
- *Sensu lato* – any mechanism by which parents modify the phenotype of their offspring



# The developmental niche

“genes inherit a rich and supportive environment... The niche is a legacy bequeathed to progeny and responsible for the diverse but dependable influences on the developing organism.”

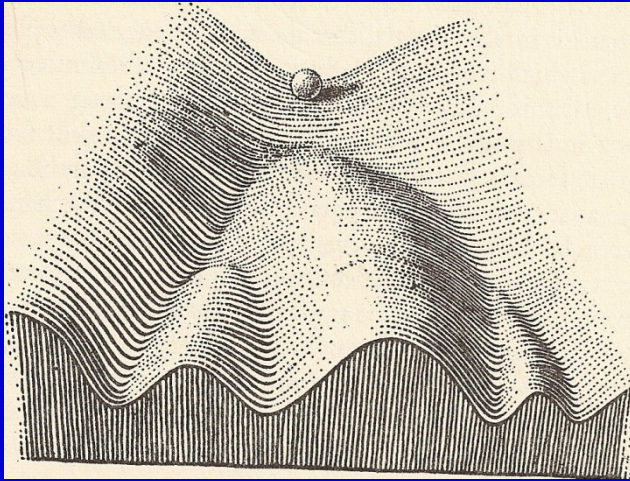


Brown-headed cowbird (*Molothrus Ater*)

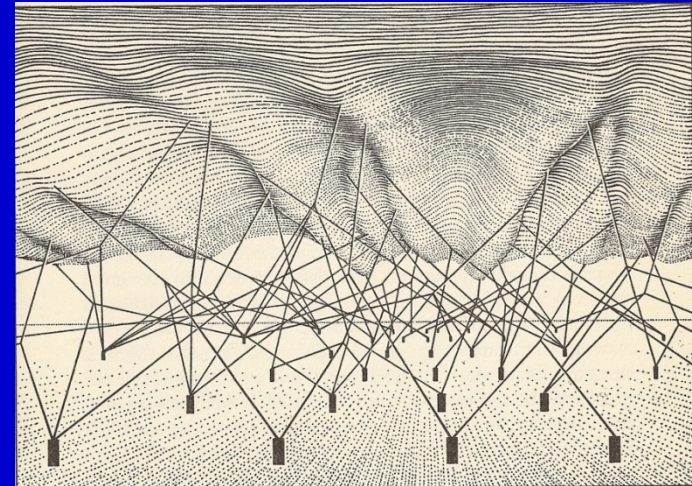
West, M. J., & King, A. P. (1987). Settling nature and nurture into an ontogenetic niche. *Developmental Psychobiology*, 20.



# Developmental systems



Waddington 1957



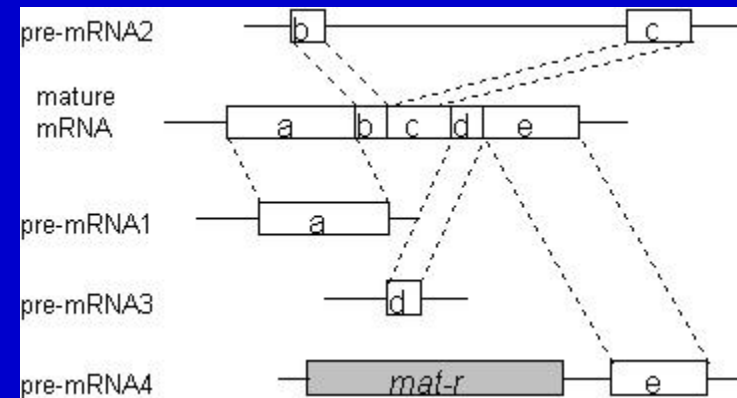
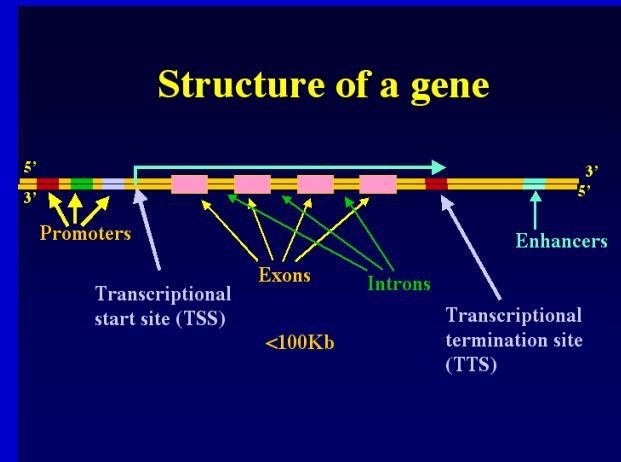
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Conrad Waddington *The Evolution of Developmental Systems* 1952

# Why are genes special?

- Nominal genes (2% of genome) are heritable template resources for the assembly of gene products
- There is a literal ‘genetic code’ for the primary structure of proteins, but most other uses of the term ‘genetic program’ are metaphorical and/or tendentious
- The time and tissue dependent expression of multiple products from each gene is regulated by a control architecture which involves not only much of the rest of the genome, but also the factors outlined in previous slides



# Folkbiology and folk-genetics

- ‘Folkbiology’ is part of cognitive anthropology – it is the study of extra-scientific thought about living things
  - Atran, *Cognitive Foundations of Natural History*, 1990
  - Medin and Atran, *Folkbiology* 1999
- Typical claims:
  - Characteristic four-level folk taxonomies
  - The folk-specific level is ‘inductively privileged’
  - Psychological essentialism about living things

