NATURAL SELECTION AND ADAPTATION

Origins and Evolution of Language
2021 week 2

ADMIN NOTES

Tutorials start… this week? Stay tuned…

There is only one Learn page – you have not been put on the Honours course by mistake

Keep checking the webpage!

Tell me if you have accessibility requirements which aren't being met!

QUESTIONS ARISING FROM THE READING

TopHat has its issues - at the moment, you can't see question feedback (but I'm working on this)

Because this isn't visible at the moment, leave questions in the feedback that you would like me to go over (in addition to more general comments)

QUESTIONS ARISING FROM THE READING

Go over terms!

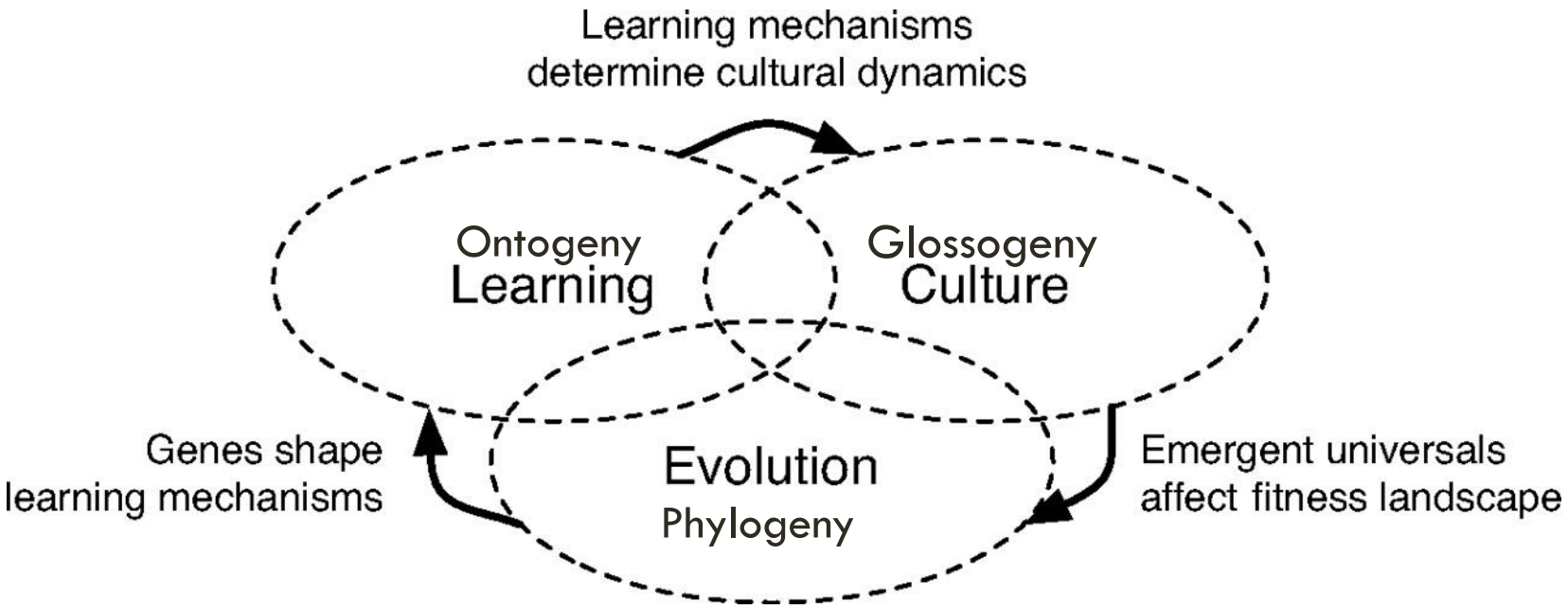
Go over Box 2.1

Explain the relevance of game theory

Multiple theories/controversy in evolution, how do these relate to language?

FLN vs FLB

TERMS



Today: Analagous (convergent), homologous, selection, variation, adaptation, exaptation, spandrel

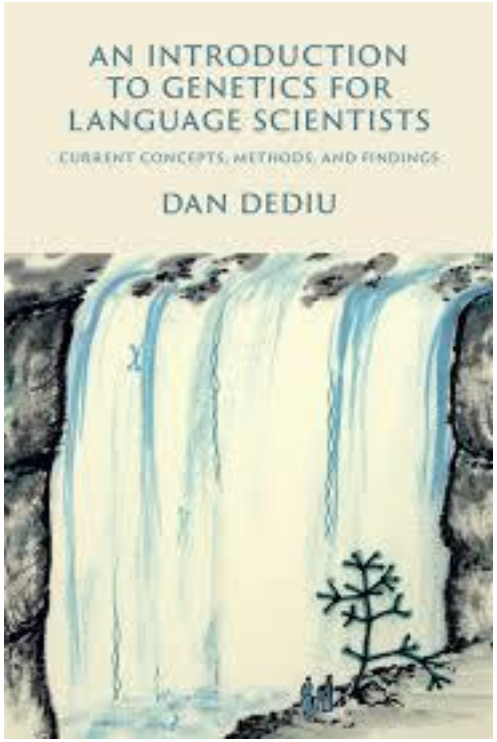
GENETICS (BOX 2.1)

If you're interested in this, have a closer look

Don't worry too much about the details of this for this course (Foundations covers more of this)

The takeaway:

- DNA is the building blocks, codes for amino acids, which code for proteins - proteins build everything
- Redundancy in coding for amino acids makes DNA robust (64 triple nucleotide codes, only 20 amino acids)
- There is a lot we don't understand about how genes work, especially for behaviour



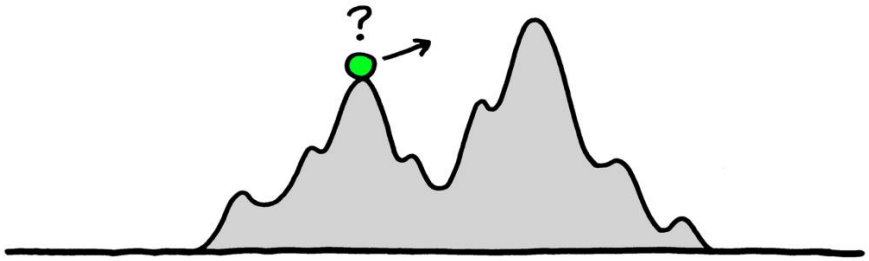
GAME THEORY

If you're interested in more detail, the Nicky Case has a great game of this (and a lot of other stuff): https://ncase.me/trust/

- If you're in Foundations, just wait for week 5!

The takeaway for this course:

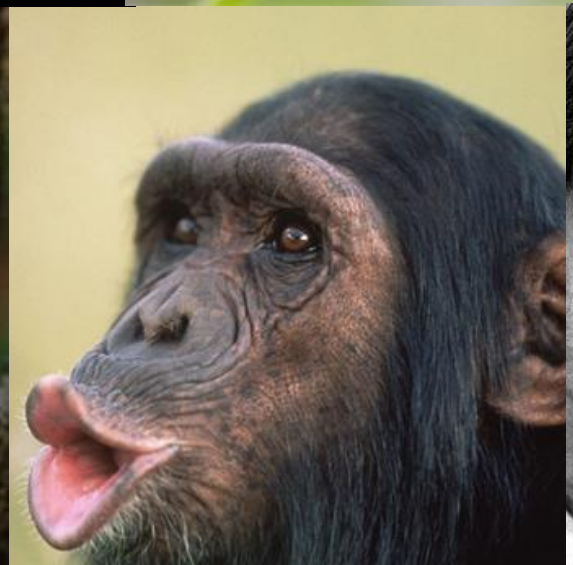
- Evolution can result in suboptimal solutions - if an ESS is reached, it may act as local optimum, which cannot be overcome
- Also some social/trust implications



COMMUNICATION IS WIDESPREAD, LANGUAGE IS UNIQUE (?)



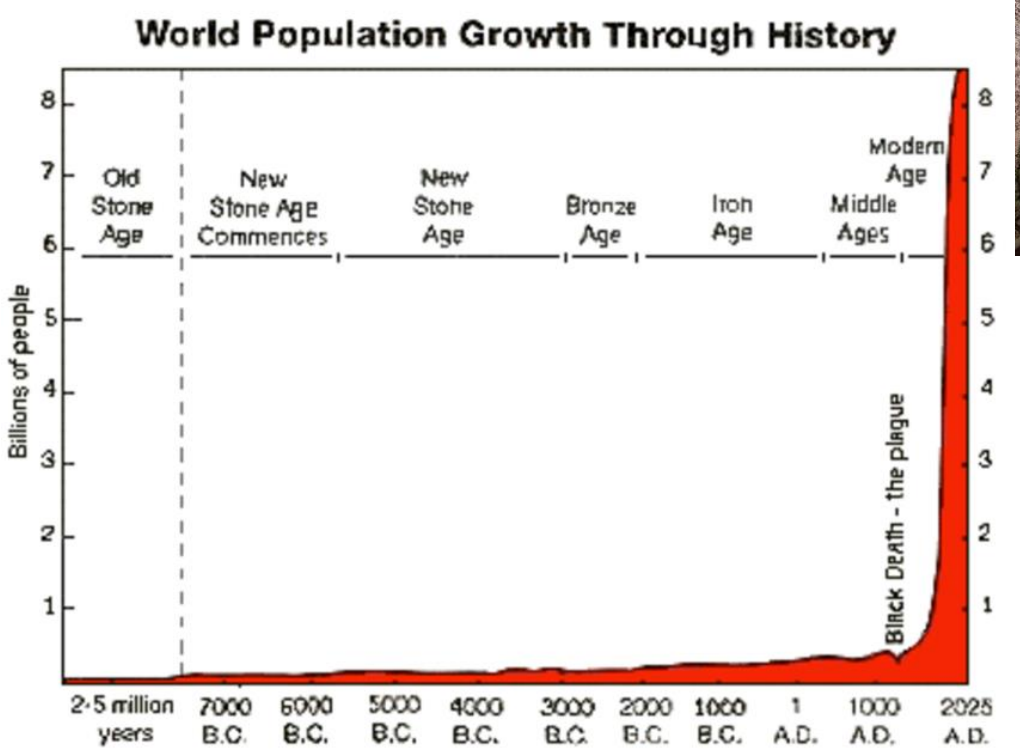





UNIQUE, UNIVERSAL, ADAPTIVE

Universal in humans

Highly adaptive



EVOLUTION BY NATURAL SELECTION

Reproduction: organisms reproduce to form new generations

Variation: individual organisms may be similar, but are not identical to one another.

Heredity: characteristics that vary from individual to individual are passed on from parents to offspring

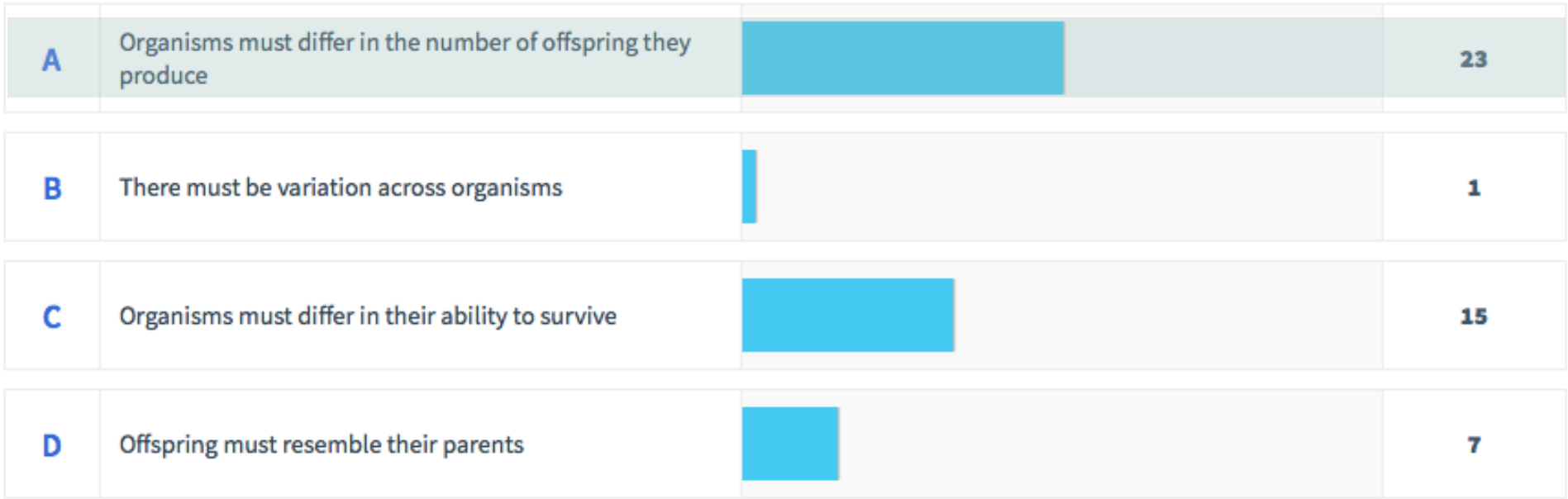
Competition: Not all individuals leave the same number of offspring; not all individuals have the same representation in the next generation i.e., there is also variation in reproduction)

Natural Selection

"As long as individuals' success in survival and **reproduction** depends at least partly on the characteristics they have (which **vary,** and are **heritable**), then characteristics which **confer an advantage** in survival will increase in frequency while those conferring disadvantage will disappear - those which have no effect on survival will not be subject to selection." - *Nettle, 2009, p.13*

EVOLUTION BY NATURAL SELECTION

Which of the following is NOT required for natural selection to take place?



REPRODUCTION
HEREDITY
VARIATION
COMPETITION

"If these conditions are met, for any property or species, natural selection automatically results. If any conditions are not met, natural selection does not result. … When all four conditions apply, the entities with the property conferring higher fitness will leave more offspring, and the frequency of that type of entity will increase in the population"

-Ridley, *Evolution*, p. 71-72

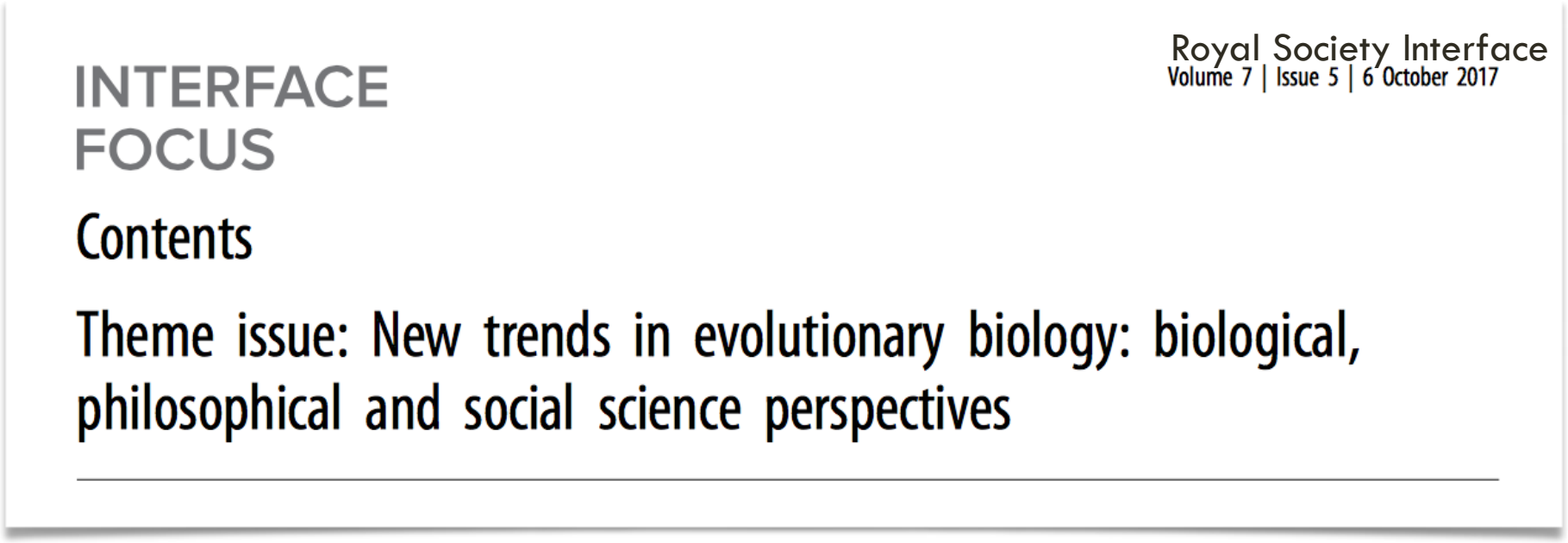
MULTIPLE THEORIES OF EVOLUTION?

Not really - evolution by natural selection is the main, unifying theory of evolution. No one really disagrees about this.

But: this is a simple, broad framework - lots of room for disagreement about/refinement of detail:

- Where/on what does selection happen?
- Where do selective pressures come from? What are they? How do we detect them?
- How are traits inherited/transmitted?
- How is variation constrained, maintained, or introduced?
- What is the locus of competition?

CONTROVERSY IN EVOLUTION



INTERFACE
FOCUS

Royal Society Interface
Volume 7 | Issue 5 | 6 October 2017

Contents

Theme issue: New trends in evolutionary biology: biological, philosophical and social science perspectives

Laland et al. (2014). Does evolutionary theory need a rethink? Nature News, 514 (7521): 161-164.

ADAPTATIONS

"'design' in life; those properties of living things that enable them to survive and reproduce" Ridley, 1996, *Evolution*

"An adaptation is a characteristic that enhances the survival or reproduction of organisms that bear it…a characteristic that has evolved by natural selection." Futuyama, 2009, *Evolution*

"All adaptation is caused by natural selection…only natural selection can lead to Adaptation" Barton, 2007, *Evolution*

ADAPTATION AND DESIGN

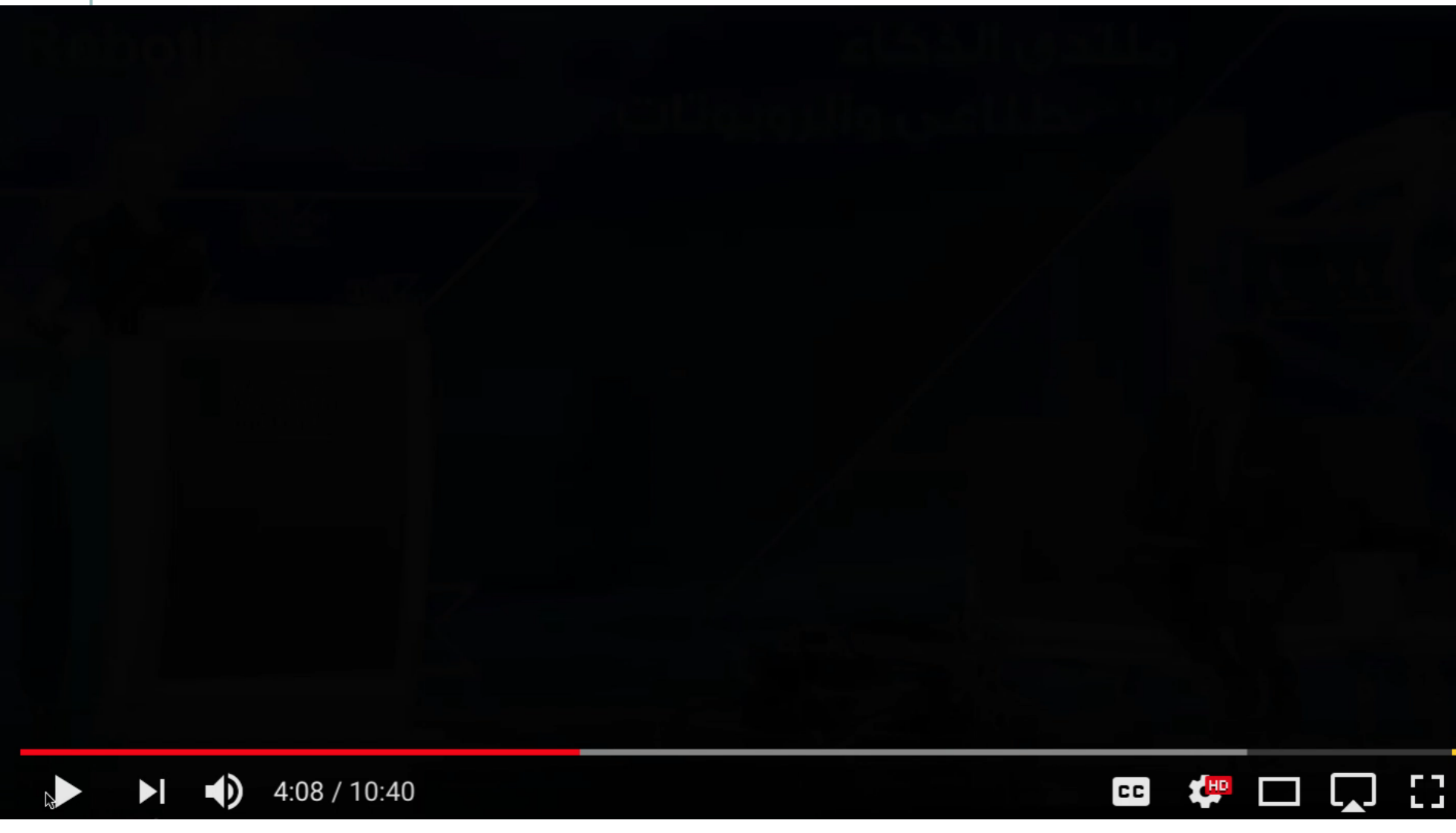
Adaptations are traits designed to serve a function which increases fitness

Contribute to the appearance of design

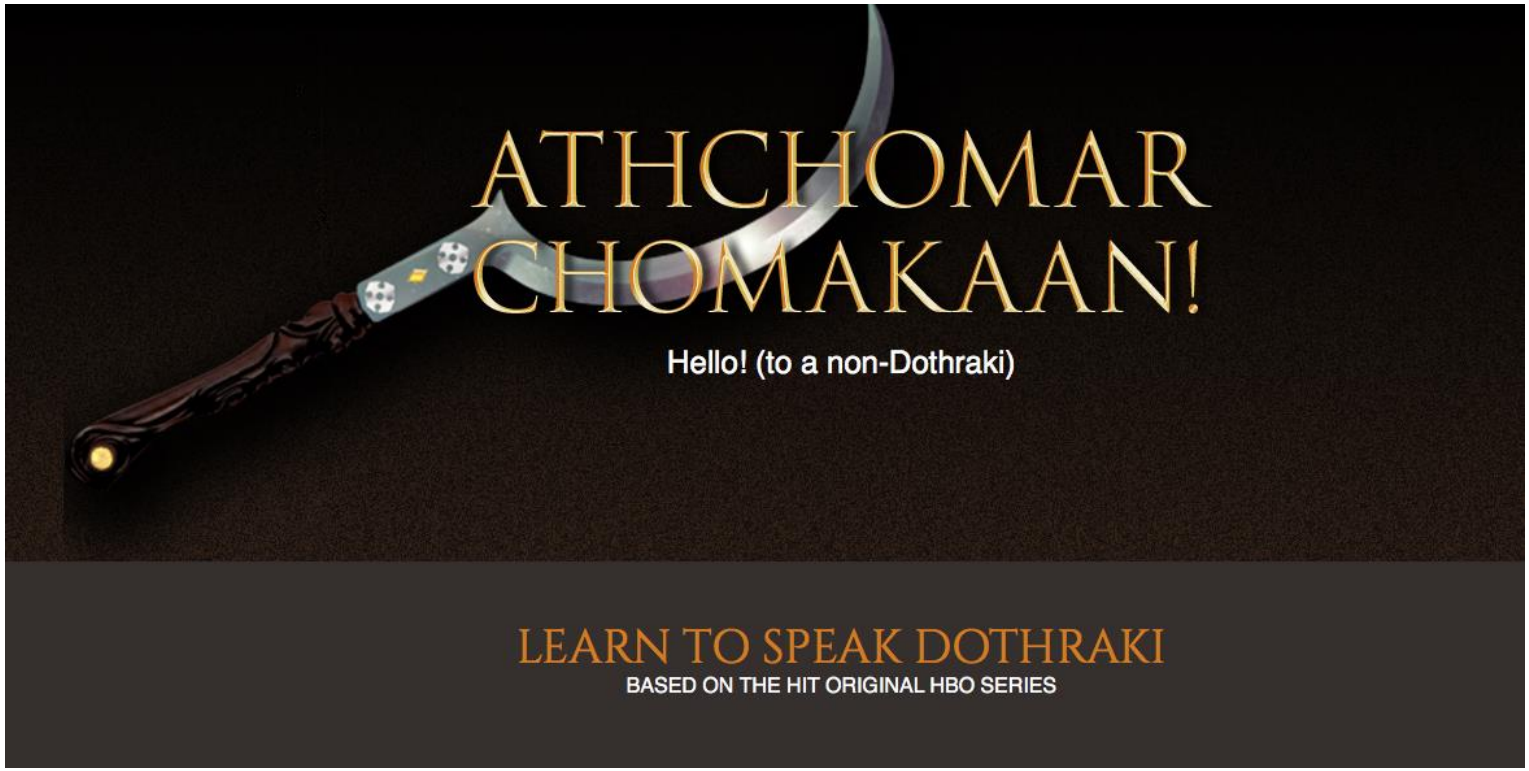
Not only appear designed, but *well* designed

- Self-sustaining, reproducing, autonomous, deal with hostile, changing environments
- This is not easy.

DESIGN IS HARD



DESIGN IS HARD



NATURAL SELECTION AND ADAPTATION

Natural selection produces well designed adaptations

- (arguably better designed than some designed things)

Sometimes designers use this, e.g.,

- bioengineering
- iteration in marketing

Where do adaptations come from?

VARIATION

Generated/maintained by sexual reproduction (meiosis and recombination)

Mutations (though more rarely relevant than sci-fi would have you believe)

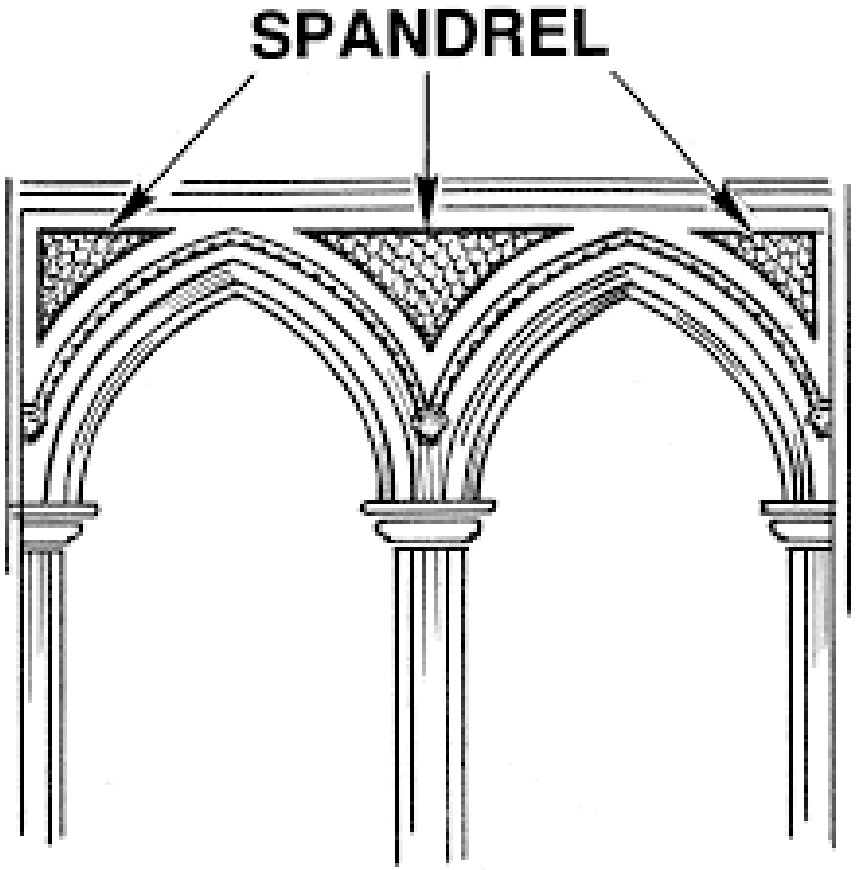
Physical distributions of organisms

SPANDRELS

Examples?

Really a theoretical construct

Complicated by the fact that once something has a function, it's hard for us to un-see



EXAPTATION

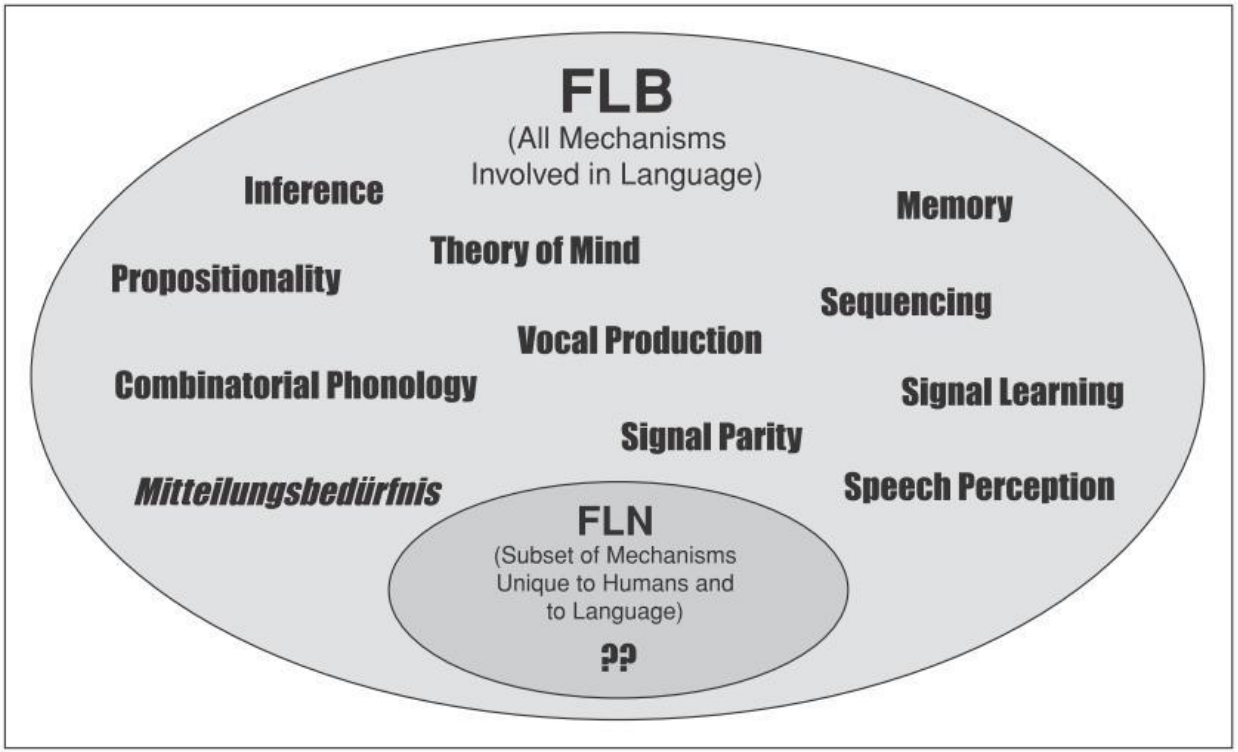
Exaptation is the process by which an existing trait can be repurposed for a new function, and become an adaptation

Exaptations could come from other adaptations, or spandrels

EXAPTATION AND SPANDRELS IN LANGUAGE?

Gould (1997) suggested language was a spandrel

Fitch (2010) suggests many traits exapted



FLN/FLB?

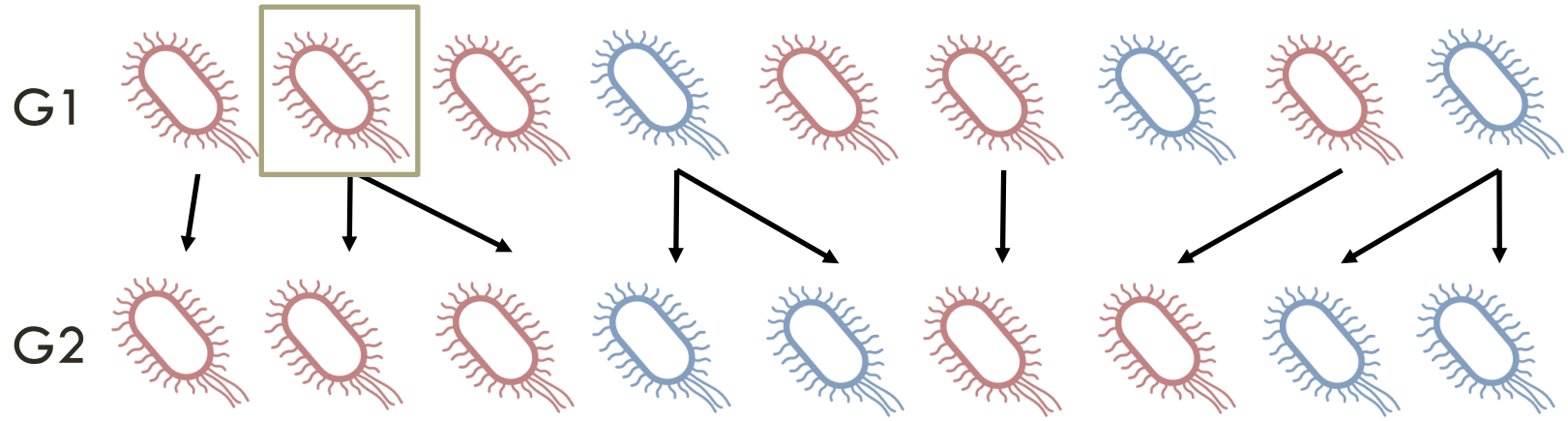
Not actually a widely used distinction in language evolution

FLN wasn't always empty (e.g., Hauser, Chomsky, and Fitch, 2002)…has progressively become emptier

Word is Fitch would now be happy with the idea that there is nothing in it

Chomsky used to say recursion, now would (probably?) say merge

UNDERSTANDING FITNESS



What is the fitness of this bacteria?

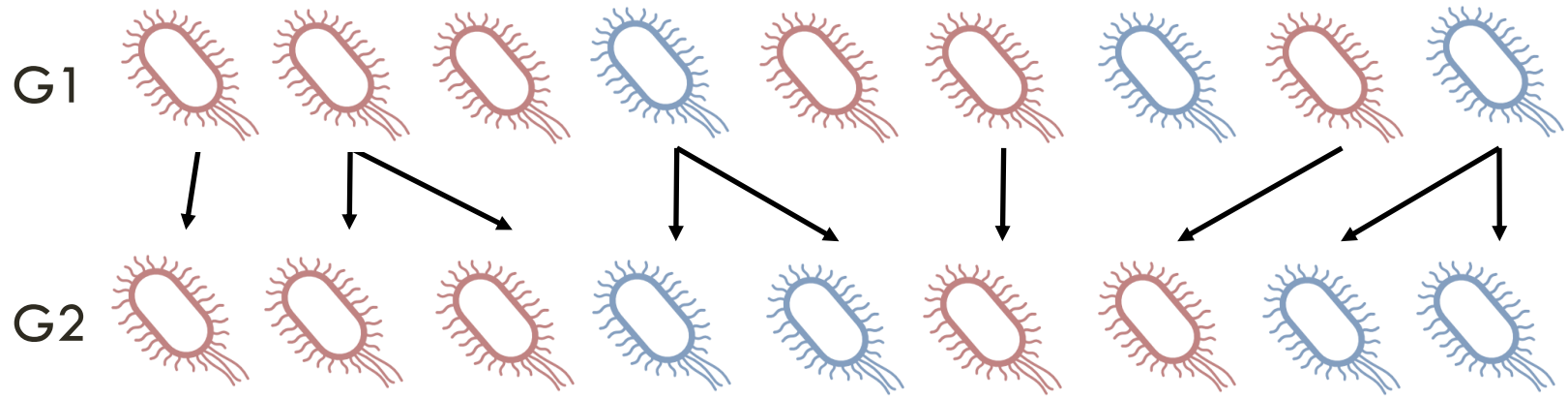
A. 0

B. 1

C. 2

D. 3

UNDERSTANDING FITNESS



What is the average fitness of red bacteria?

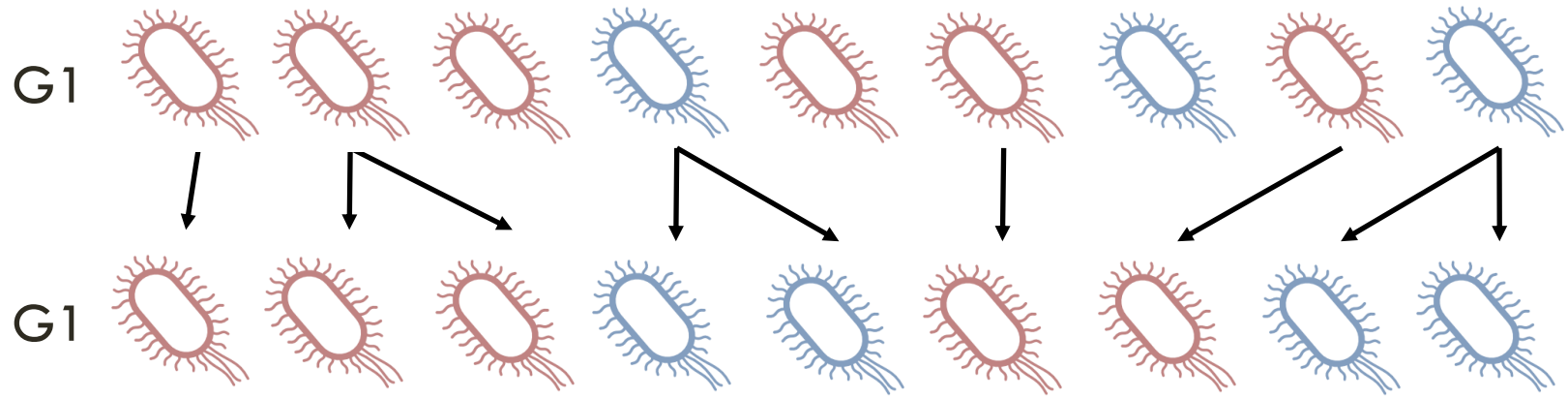
A. 5

B. 5/6

C. 5/4

D. 6/5

UNDERSTANDING FITNESS



What is the average fitness of blue bacteria?

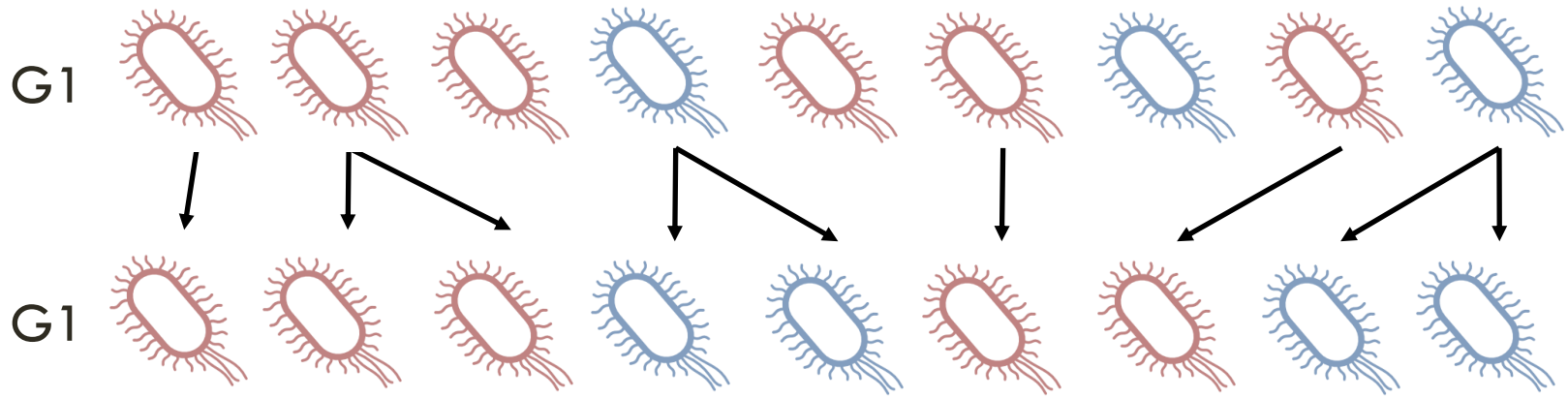
A. 4/3

B. 3/4

C. 4

D. 3

UNDERSTANDING FITNESS



If these average fitness numbers are accurate, what would you expect the population to look like in G3 (roughly)?

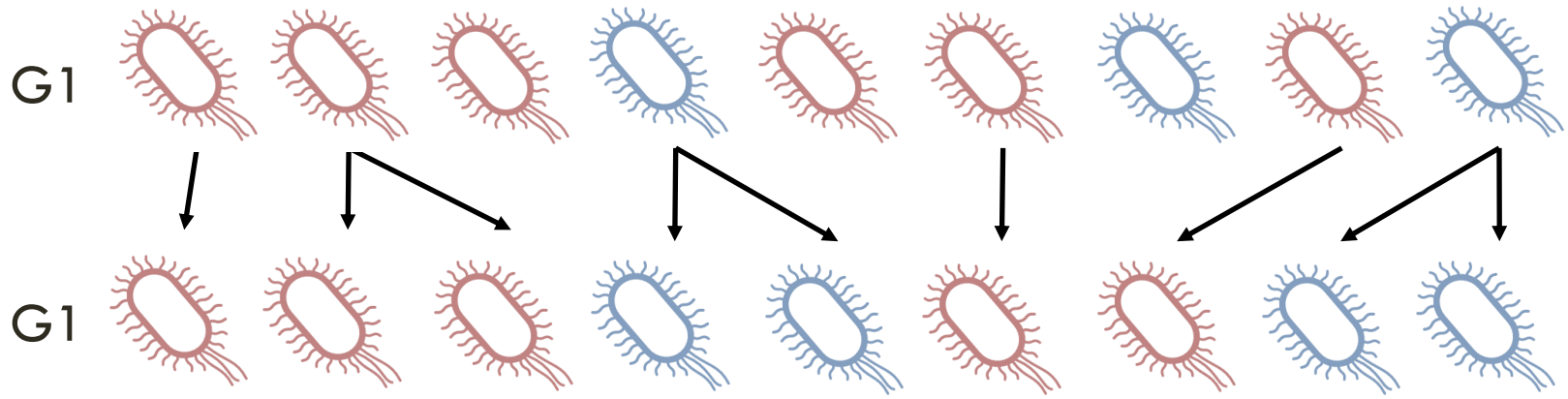
A. 6 red, 3 blue

B. 5 red, 4 blue

C. 4 red, 5 blue

D. 3 red, 6 blue

UNDERSTANDING FITNESS



What would you expect the population to look like a long time in the future?

A. Mainly red bacteria

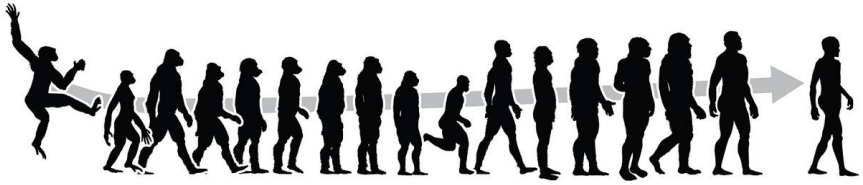
B. Mainly blue bacteria

C. A mix of red and blue bacteria

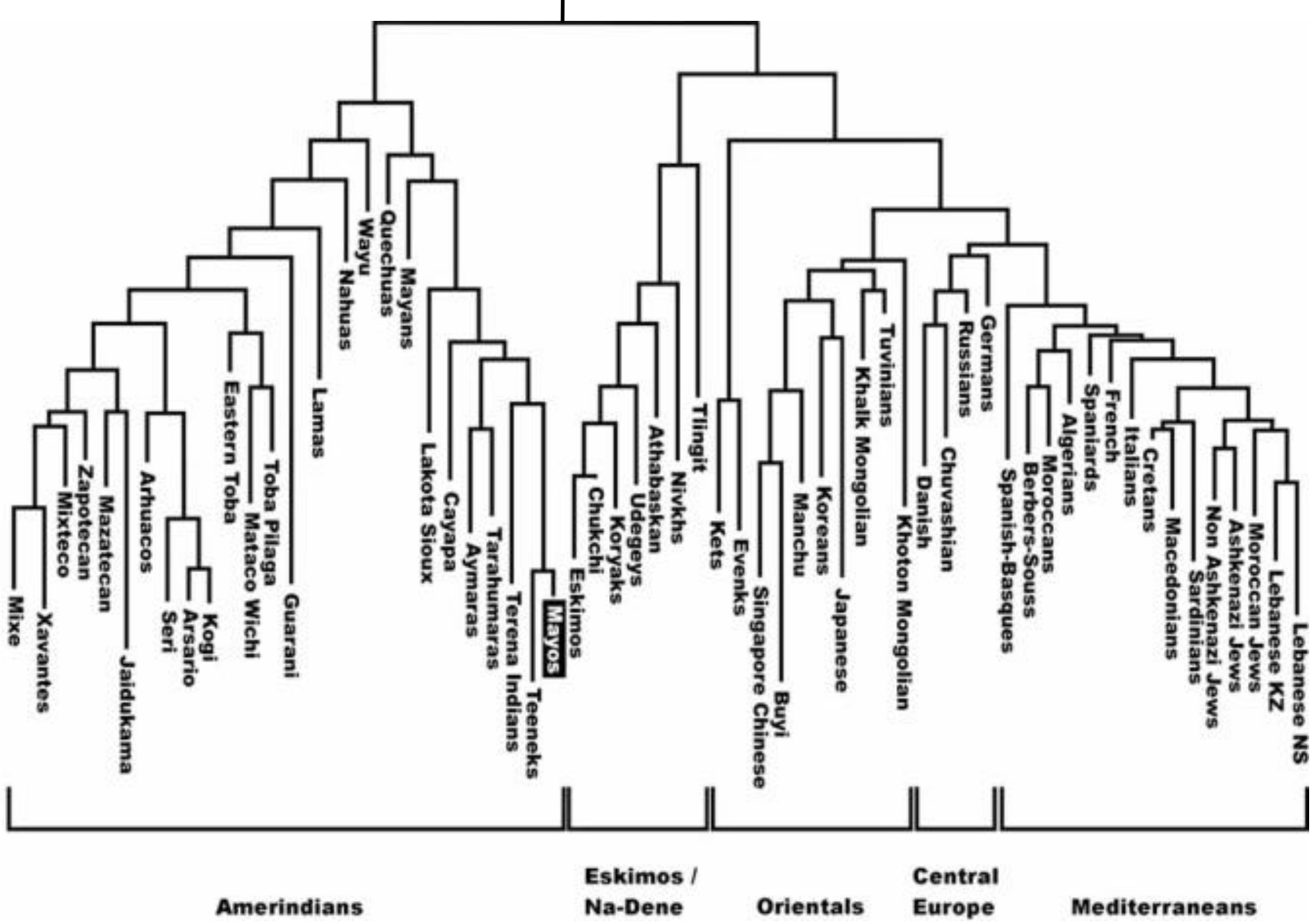
EVOLUTION: DESCENT WITH MODIFICATION

This is what evolution looks like.

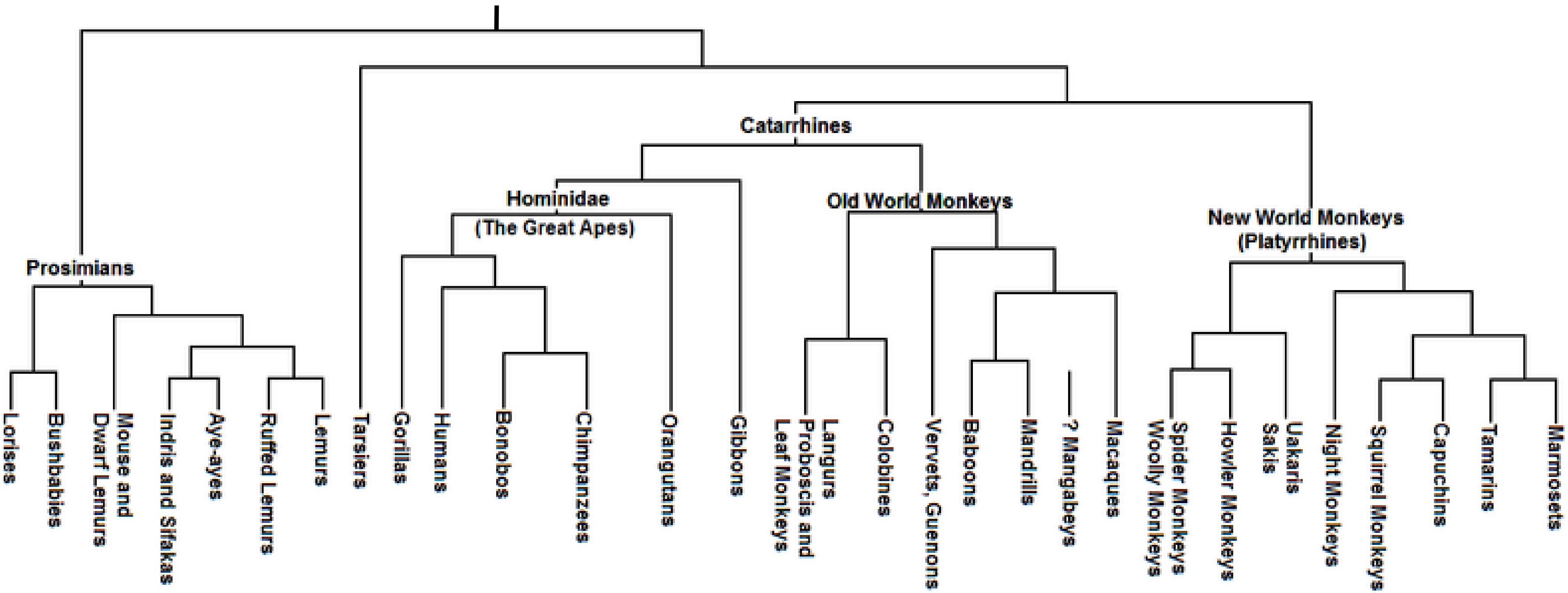
This is not what evolution looks like.



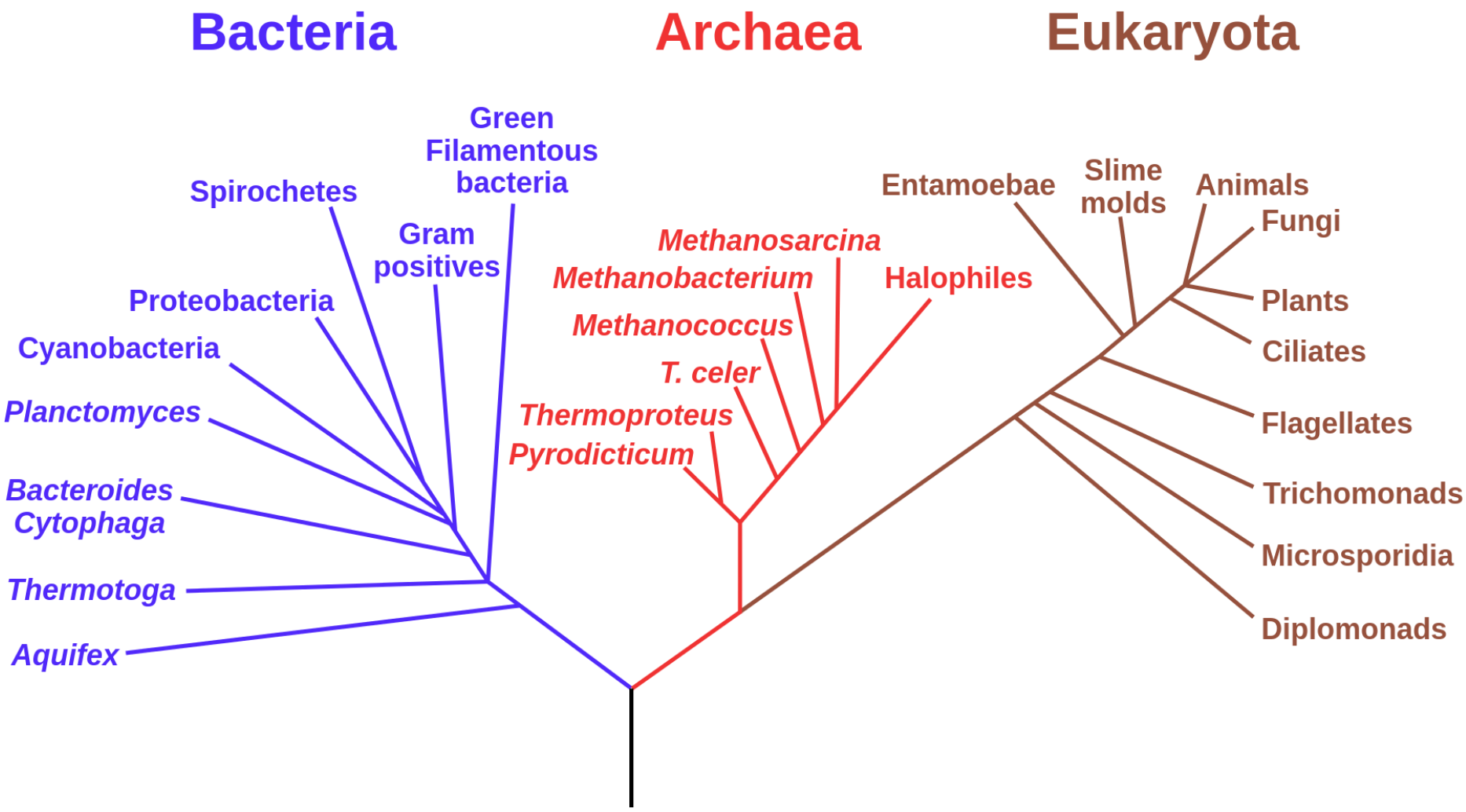
T. Michael Keesey https://www.flickr.com/photos/keesey/



Arnaiz-Villena et al. (2007). HLA Genes in Mayos Population from Northeast Mexico. Current Genomics, 8, 466-475.



Catarrhines
Hominidae
(The Great Apes)
Old World Monkeys
New World Monkeys
(Platyrrhines)
Prosimians
Lorises
Bushbabies
Mouse and Dwarf Lemurs
Indris and Sifakas
Aye-ayes
Ruffed Lemurs
Lemurs
Tarsiers
Gorillas
Humans
Bonobos
Chimpanzees
Orangutans
Gibbons
Langurs Proboscis and Leaf Monkeys
Colobines
Vervets, Guenons
Baboons
Mandrills
? Mangabeys
Macaques
Spider Monkeys Woolly Monkeys
Howler Monkeys
Uakaris Sakis
Night Monkeys
Squirrel Monkeys
Capuchins
Tamarins
Marmosets

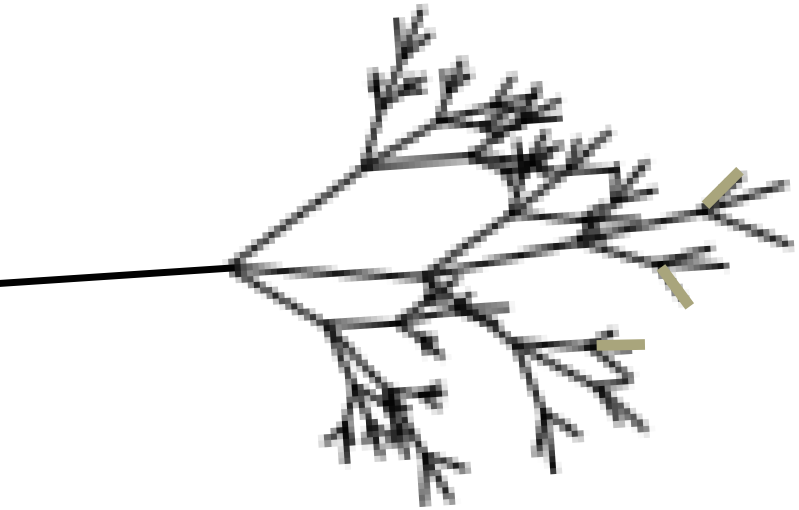


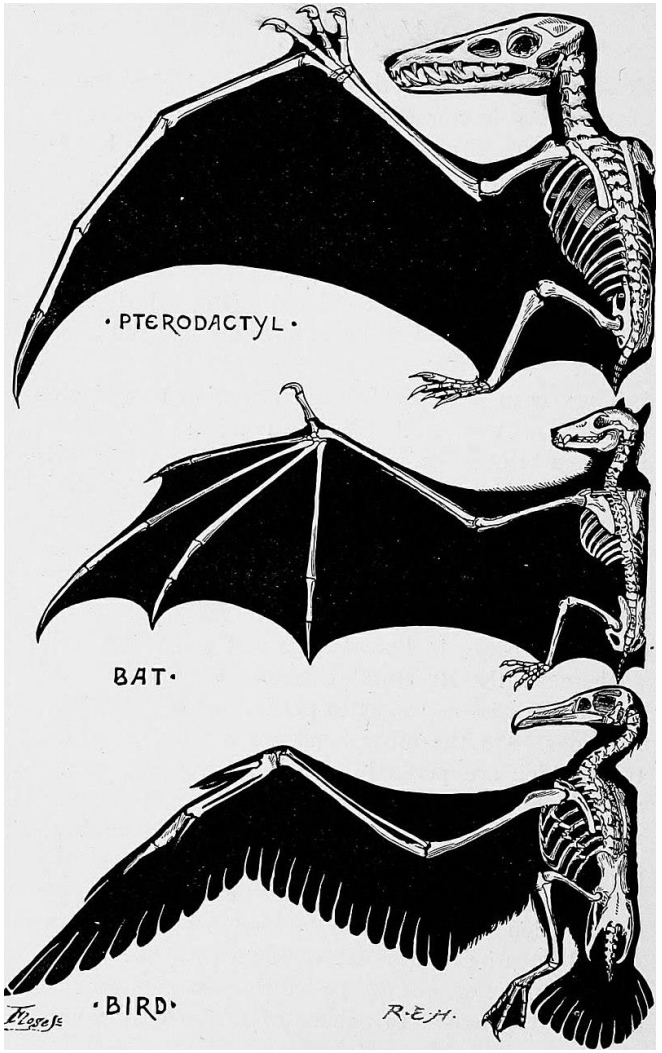
https://commons.wikimedia.org/wiki/File:Phylogenetic_tree.svg

CONVERGENT EVOLUTION

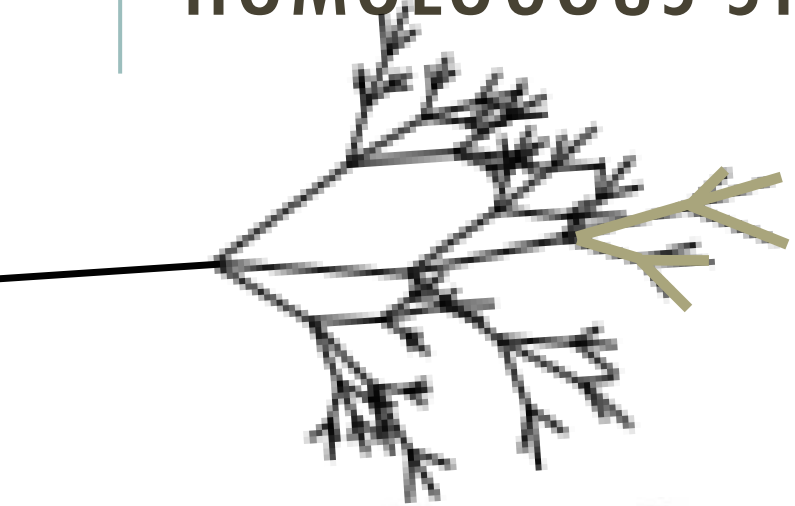
Adaptations are traits (forms) which serve a function

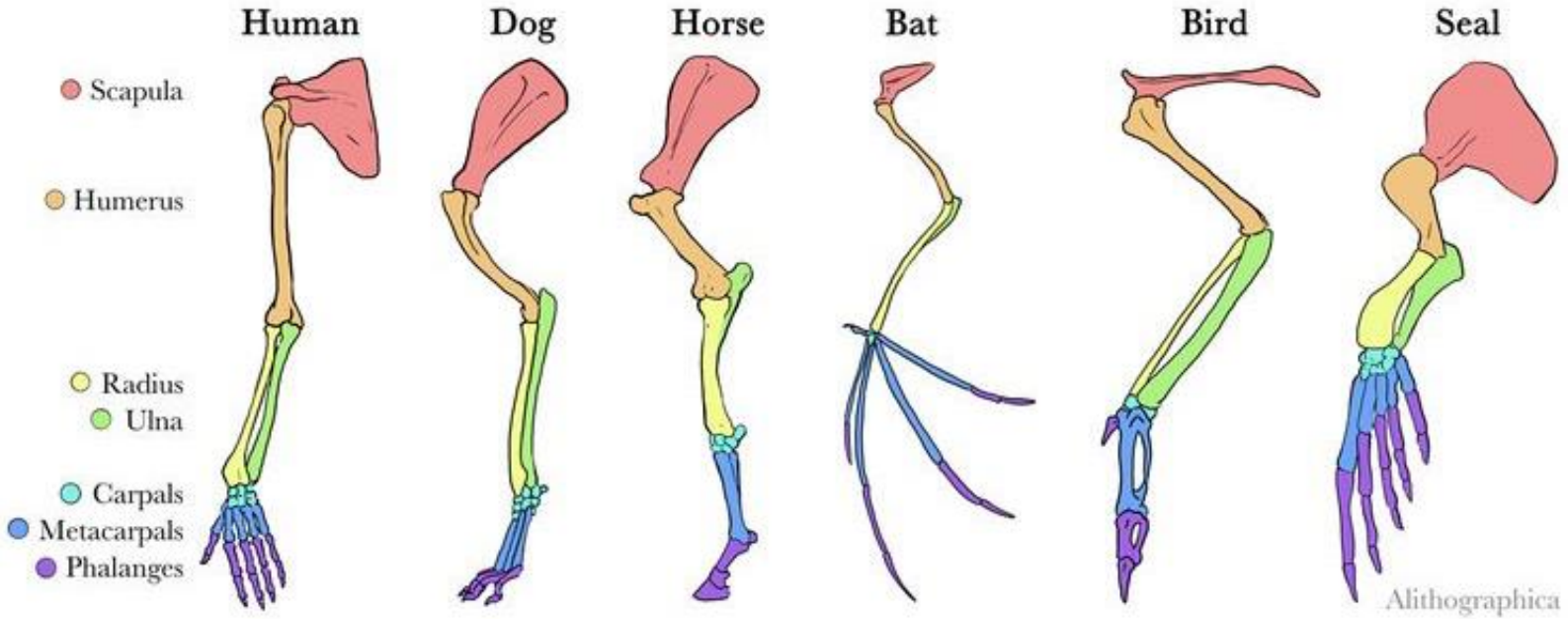
- when functions are shared, similar forms sometimes evolve
- known as analogous structures





HOMOLOGOUS STRUCTURES





-LOGUS STRUCTURES

Analogous structures: seem the same, but emerged independently

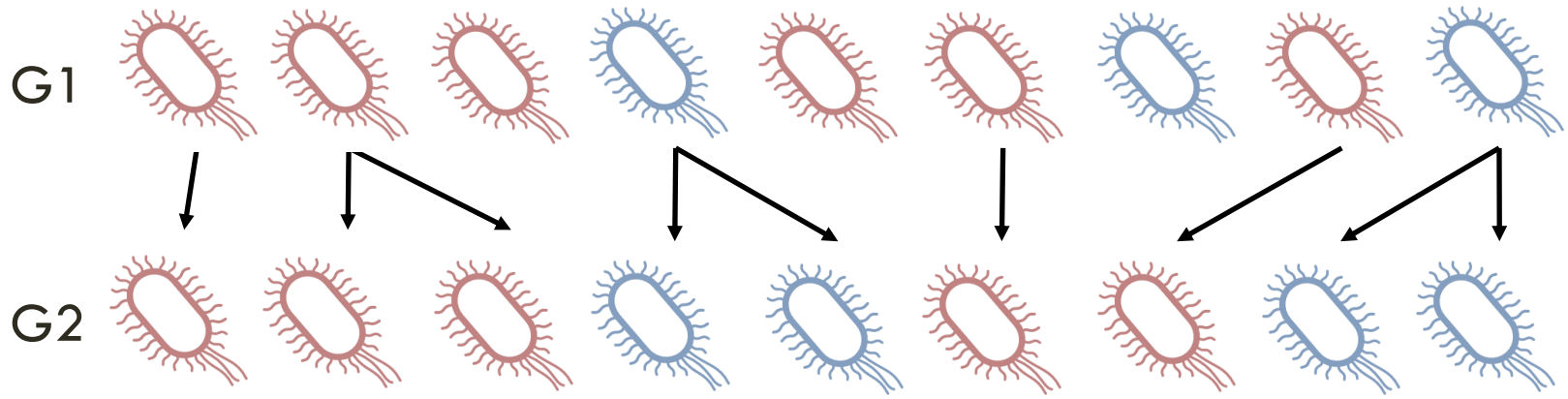
Homologous structures: (may) seem different, but share a common ancestor

UNDERSTANDING FITNESS

Fitness is defined by the number of offspring

- Can be quantified in an individual, e.g., my fitness is 2
- More commonly/usefully quantified as an average number of offspring acro a subset of the population
- In human demography, often referred to as fertility rate

UNDERSTANDING FITNESS



To the tophat….

FITNESS IN LANGUAGE

How might we quantify fitness in language?

BREAK

When we come back: selection

ARE THESE ADAPTIVE TRAITS?

SEXUAL SELECTION

A consequence of interactions between individuals in reproduction

- Competition between males for access to females
- Female selection of males based on trait/display

"sexual selection can lead to arbitrary and apparently maladaptive evolution" (Barton, 2007, p. 573)

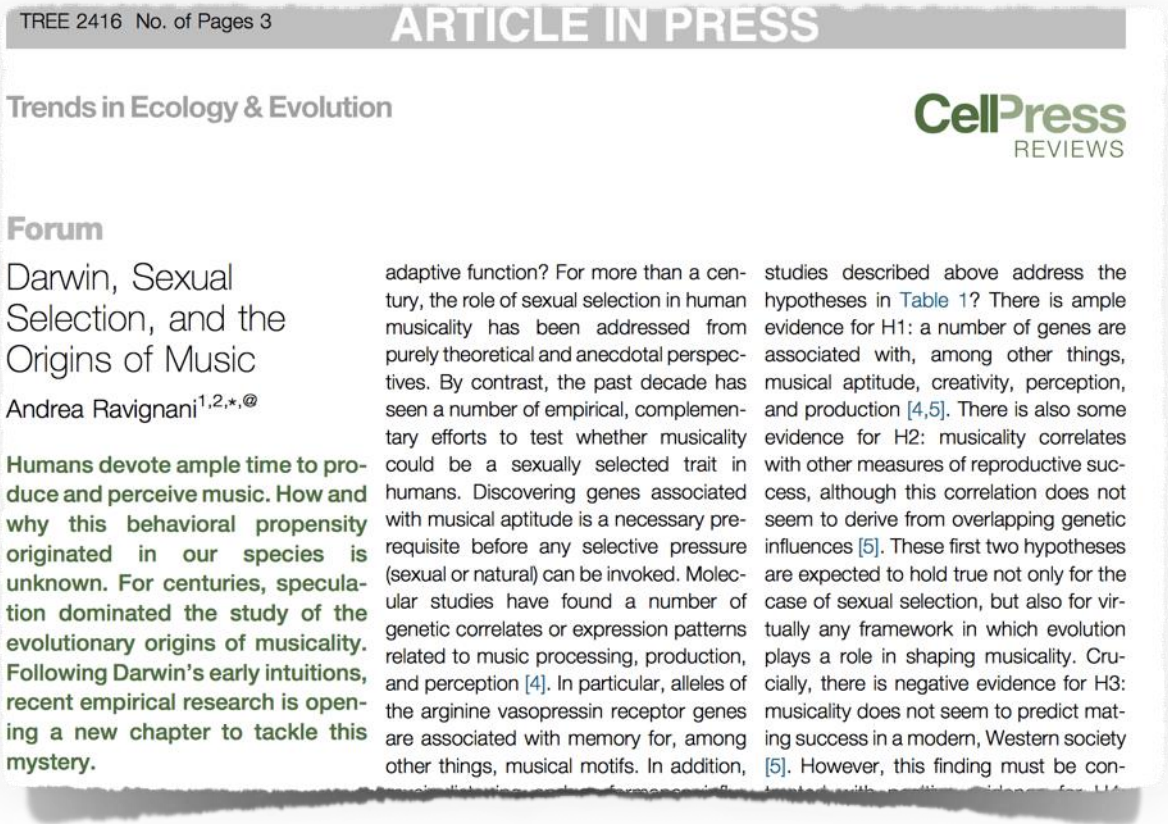
BIRD OF PARADISE

PUFFER FISH

SEXUAL SELECTION IN LANGUAGE?

Useful in courtship, unlikely to have *adapted* for it (potential mating function is low on the list)

Music?



TREE 2416 No. of Pages 3 ARTICLE IN PRESS

Trends in Ecology & Evolution

CellPress REVIEWS

Forum

Darwin, Sexual Selection, and the Origins of Music

Andrea Ravignani[1,2,*,@]

Humans devote ample time to produce and perceive music. How and why this behavioral propensity originated in our species is unknown. For centuries, speculation dominated the study of the evolutionary origins of musicality. Following Darwin's early intuitions, recent empirical research is opening a new chapter to tackle this mystery.

adaptive function? For more than a century, the role of sexual selection in human musicality has been addressed from purely theoretical and anecdotal perspectives. By contrast, the past decade has seen a number of empirical, complementary efforts to test whether musicality could be a sexually selected trait in humans. Discovering genes associated with musical aptitude is a necessary prerequisite before any selective pressure (sexual or natural) can be invoked. Molecular studies have found a number of genetic correlates or expression patterns related to music processing, production, and perception [4]. In particular, alleles of the arginine vasopressin receptor genes are associated with memory for, among other things, musical motifs. In addition, studies described above address the hypotheses in Table 1? There is ample evidence for H1: a number of genes are associated with, among other things, musical aptitude, creativity, perception, and production [4,5]. There is also some evidence for H2: musicality correlates with other measures of reproductive success, although this correlation does not seem to derive from overlapping genetic influences [5]. These first two hypotheses are expected to hold true not only for the case of sexual selection, but also for virtually any framework in which evolution plays a role in shaping musicality. Crucially, there is negative evidence for H3: musicality does not seem to predict mating success in a modern, Western society [5]. However, this finding must be con-

WHAT IS THE UNIT OF SELECTION?

The individual?

- Individuals should only engage in behaviours that result an a direct benefit to their reproductive fitness

But…we observe cooperation:

- A behaviour beneficial to an organism other than the actor, and *selected for because of this benefit*

Some forms of cooperation are obvious, e.g., symbiosis

- Altruism: cost to the actor, but only obvious benefit to another individual - what is selective benefit?

ALTRUISM

Social insects?

Why should anyone risk their life for anyone else?

Why share anything? Food? Resources? Information?

- Relevant unit for selection is the gene, not the individual

‘BENEFIT’ AND ‘INDIVIDUAL’

Fitness benefit: increase in reproductive success (i.e., representation in the next generation)

Individual: composed of a specific genome, but

- Any given individual shares some genes with other individuals in the population

‘altruistic’ behaviour = fractional self-preservation

KIN SELECTION

Parental altruism: benefit is obvious, 50% share of genes, and reproduction is the whole point

Also works for other relatives. For any relative there is a **coefficient of relatedness**: the probability that a variant will be shared with a relative

r	relationship
0.5 (½)	parent-offspring
0.25 (¼)	grandparent-grandchild
0.125 (⅛)	great grandparent-great grandchild
1	identical twins; clones
0.5 (½)	full siblings
0.25 (¼)	half siblings
0.125 (⅛)	first cousins
0.03125 (1/32)	second cousins[3]

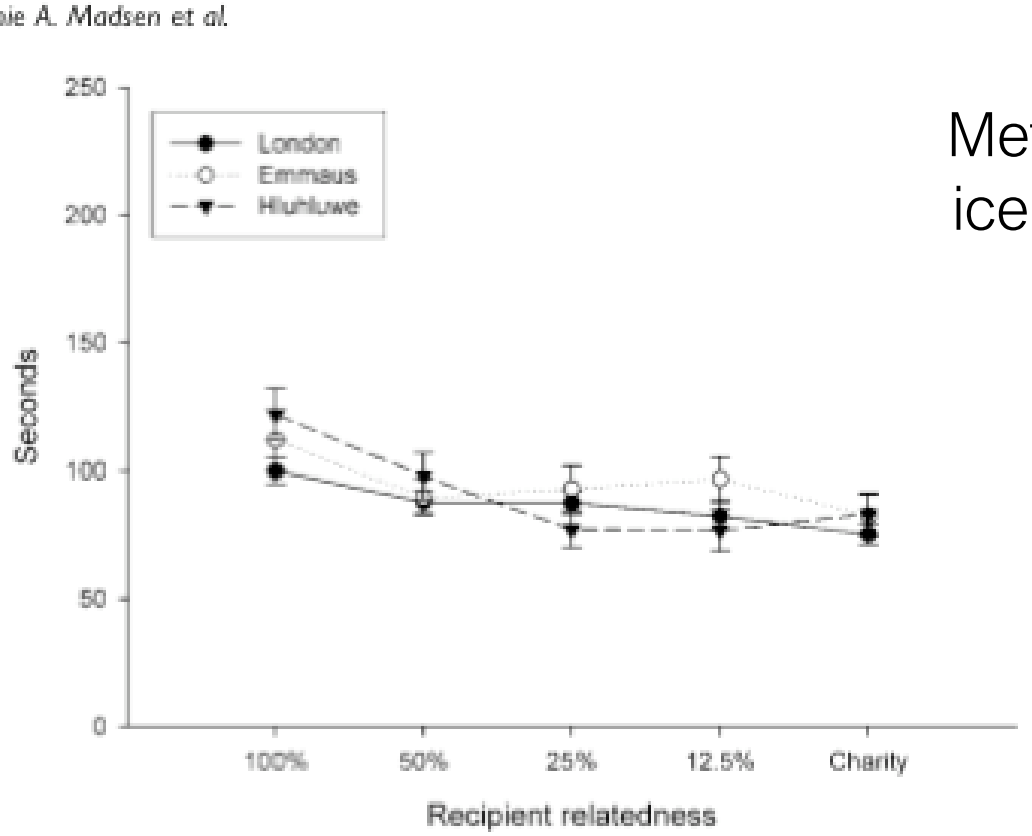
HAMILTON'S RULE

- r=relatedness of recipient to actor (probability that the two share a given gene variant)
- b= benefit to recipient,
- c=cost to the actor

- A behaviour will persist as long as the product of **relatedness of the recipient to the actor** and **benefit to the recipient** is greater than the **cost to the actor**.

$$rb>c$$

KIN SELECTION IN HUMANS



Method: Shove your hand in this ice and some other person gets money

Madsen, E. A., Tunney, R. J., Fieldman, G., Plotkin, H. C., Dunbar, R. I., Richardson, J. M., & McFarland, D. (2007). Kinship and altruism: A cross-cultural experimental study. *British Journal of Psychology*, *98*(2), 339-359.

KIN SELECTION IN HUMANS

Not well replicated, many studies use self-report, unrealistic conditions with strange proxies for 'benefit'

Importantly, not deterministic:

> "Kinship…represents a baseline against which individuals pitch other criteria (including reciprocity, prosociality, obligation and a moral sense) when deciding how to behave towards others."
> Madsen et al. (2007), p. 339

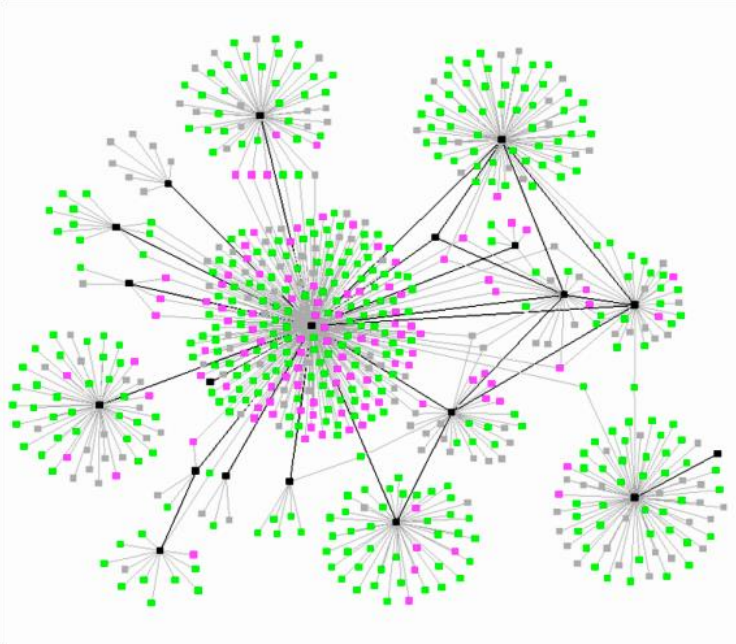
‘KIN’ SELECTION

What do we mean by kin?

Relatedness traditionally calculated as strictly genetic.

However especially in prosocial species (like humans), social relatedness is important

- Prosociality is an adaptation



LANGUAGE SIGNALS SOCIAL RELATEDNESS

Biological Theory
June 2008, Volume 3, Issue 2, pp 174–183 | Cite as

Language and the Free-Rider Problem: An Experimental Paradigm

Authors | Authors and affiliations

Gareth Roberts

Article
First Online: 20 March 2015

RECIPROCAL ALTRUISM

Altruism in the absence of relatedness - often due to evolved prosociality

In prosocial populations, costly behaviour is only *temporarily* costly

RECIPROCAL ALTRUISM

c = cost to the actor

b = benefit to the recipient

w = likelihood of reciprocation

- bw>c

A highly social brain and good memory required to keep track of w

PROSOCIALITY IS AN ADAPTATION

Humans live in social groups that go well beyond kin. Provides:

- protection against predation
- pooling of resources (food, offspring care)
- territorial defence
- information transfer

INFORMATION LOSS

The Atlantic

SCIENCE

Humans Are Destroying Animals' Ancestral Knowledge

Bighorn sheep and moose learn to migrate from one another. When they die, that generational know-how is not easily replaced.

ED YONG SEP 6, 2018

LANGUAGE LOSS

NEXT WEEK

Animal communication