Theories in evolutionary biology

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The problem: understanding the diversity of life

(http://www-images.warwick.ac.uk/about/environment/faqs/biodiversity.jpg)

The ‘spectral distribution’ of living forms

Number of species (estimated): 7–100 millions (identified and unidentified), including:

5–10 million bacteria

74,000–120,000 fungi

Among *identified* eukaryote species:

1.6 million, including:

297,326 plants, including:

15,000 mosses,

13,025 ferns and horsetails,

980 gymnosperms,

258,650 angiosperms,

1,250,000 animals, including:

1,203,375 invertebrates:

950,000 insects,

81,000 mollusks,

59,811 vertebrates:

29,300 fish,

6,199 amphibians,

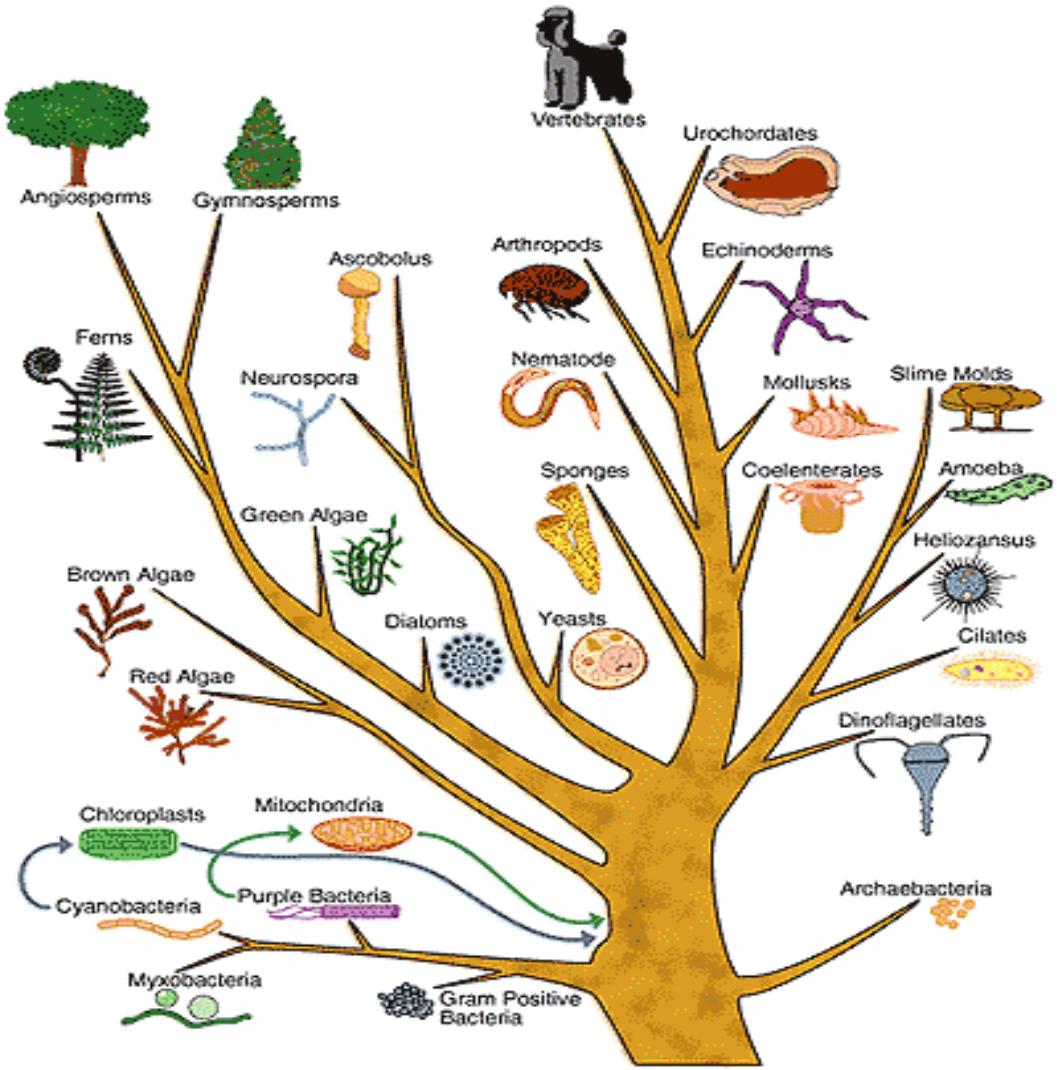
8,240 reptiles,

9,956 birds,

5,416 mammals.

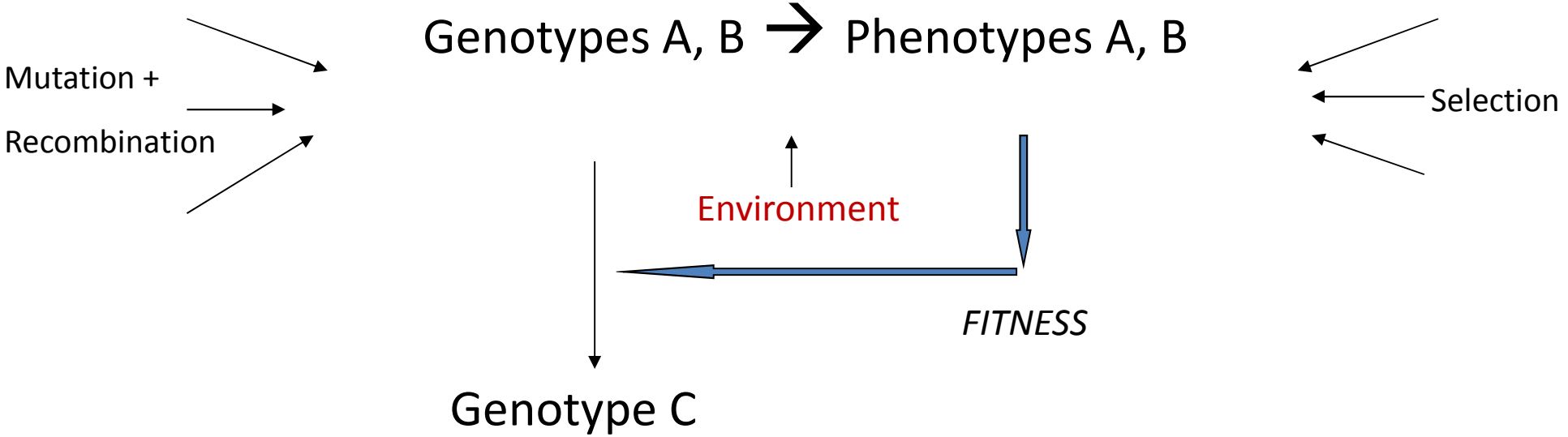
(http://www.currentresults.com/Environment-Facts/Plants-Animals/number-species.php)

Solution proposed by Darwin and Wallace .
1. Modification through descent



Principle of continuity

Solution proposed by Darwin and Wallace .
2. Natural selection



The genotype and environment together specify the phenotype

"Selfish gene"

“Null hypothesis”

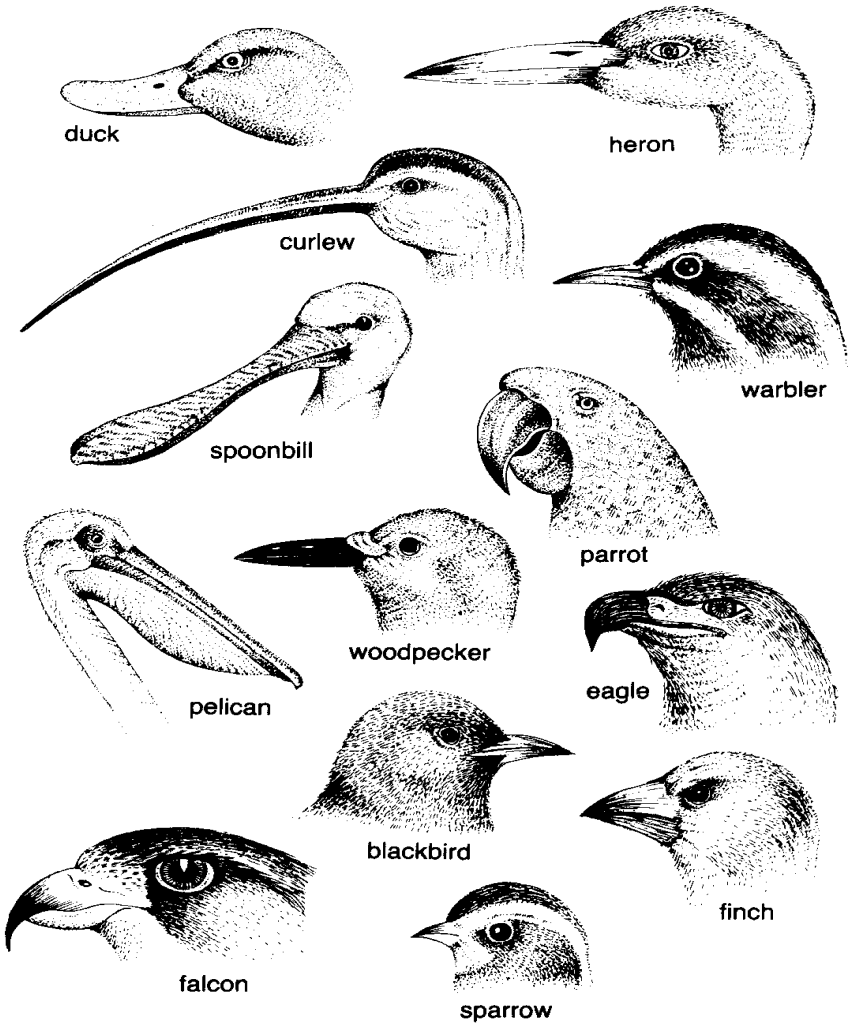
At each genetic locus,

every member of a species is homozygous

for the ‘best’ allele at that locus.

Manifestly incorrect;
genomes are ‘parliaments of genes’

The signature of natural selection: Adaptation



Adaptation works only in the short term.
Natural selection has no way of planning for the long term.

Mathematical underpinning

1. Relate phenotypes to genotypes.
2. Assign (relative) fitnesses to phenotypes .
3. Work out relative changes in phenotypes from birth to reproductive maturity.
4. Calculate haploid sperm and egg genotype frequencies following recombination.
5. Set up a table of matings.
6. Work out genotype frequencies in next generation.
7. Go back to 1.

Difficulties

1. How do genotypes map to phenotypes? (going from genes to traits)

2. How does one assign fitnesses?

Simplifications

Treat genotypes as sets of non-interacting genes;

associate fitness values with each allele at each locus;

assume large, random-mating populations.

Success of classical population genetics

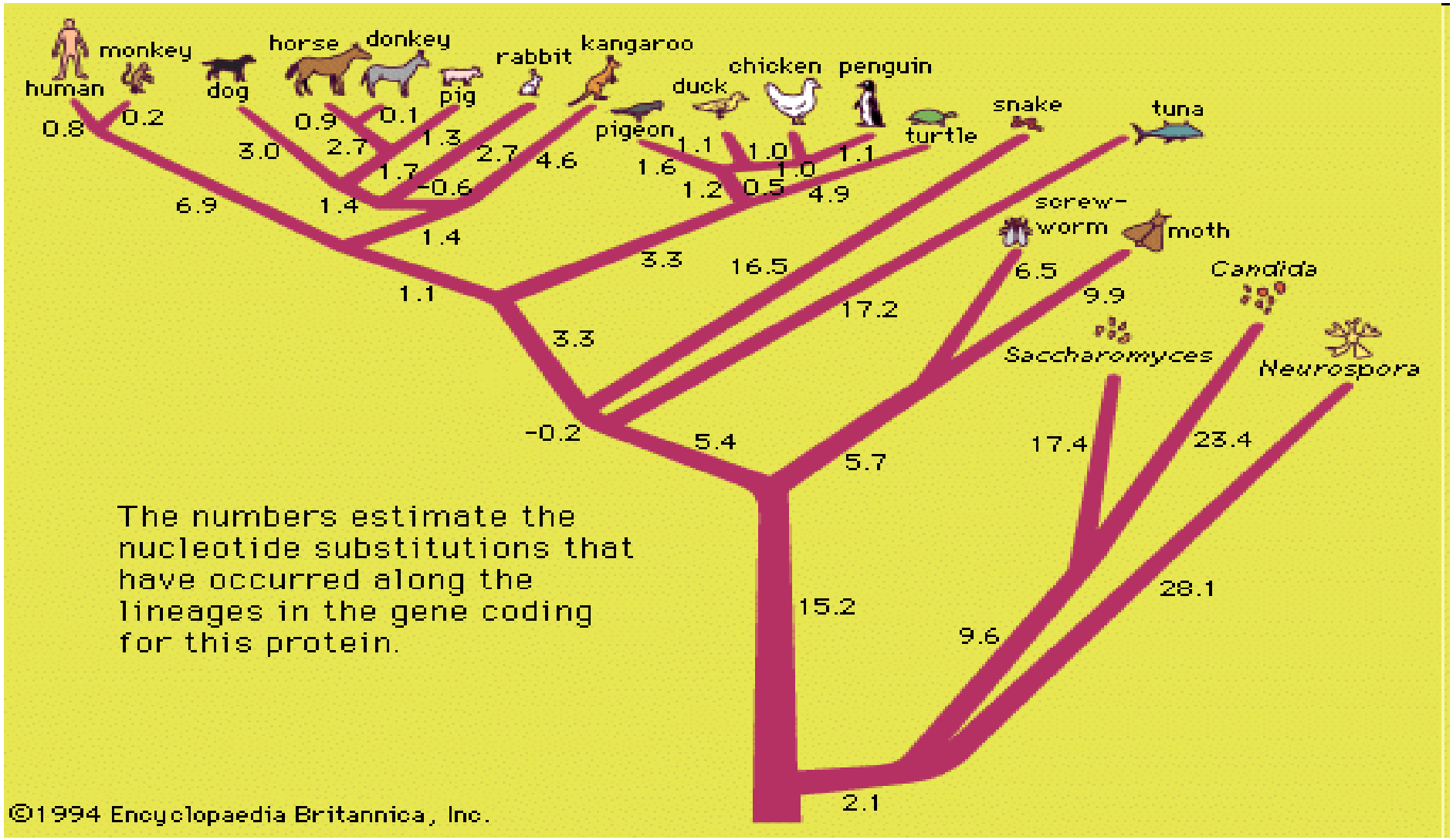
Analysis of equilibria (balance)

Fisher's fundamental theorem
(variational principle: Svirizhev, Behera)

Effects of population size
(stochastic effects)

Neutral theory of molecular evolution
(useful for building trees; coalescence)

‘Molecular’ tree-building: overlap with classical trees



philosophy.wisc.edu

Fisher's
"Fundamental theorem of population genetics"

Given certain assumptions,

The rate of increase in fitness of any organism at any time

is equal to

its genetic variance in fitness at that time.

Features not accommodated by neo-Darwinian theory

Epigenetic inheritance

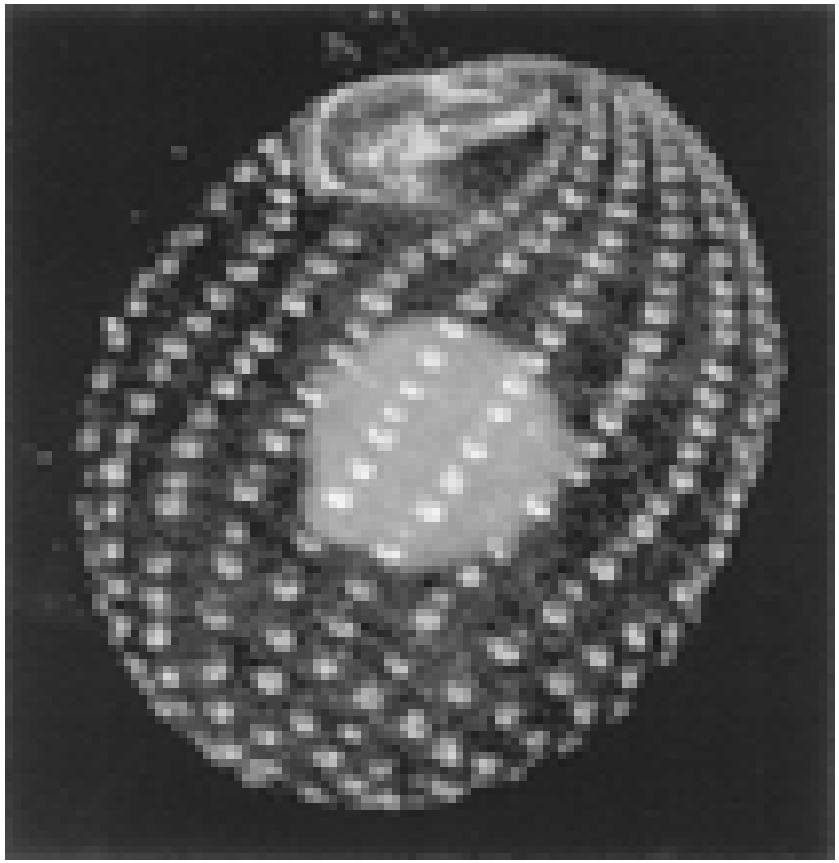
Mongolian gerbil:

masculinisation of female foetus exposed to male hormones ➔

male-biased sex ratio ➔

Increased likelihood of masculinisation

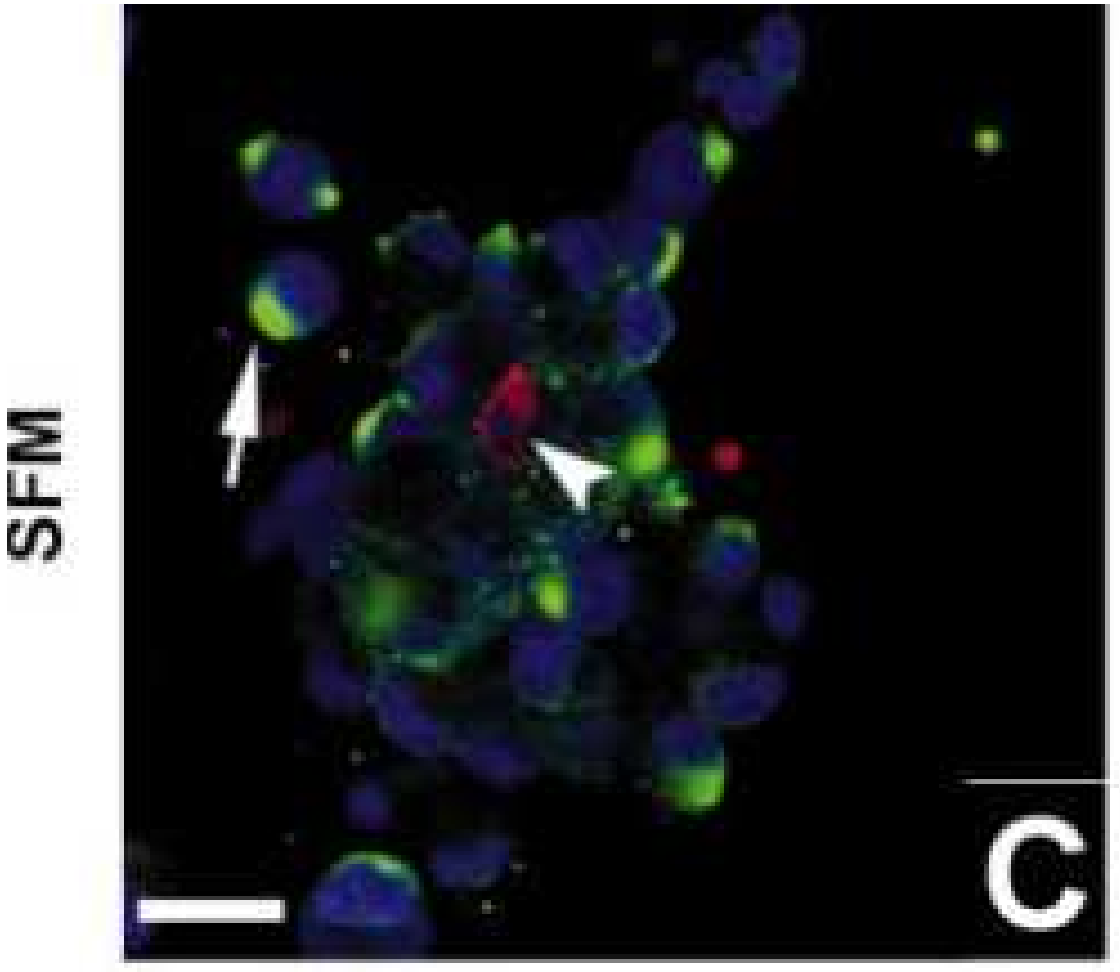
Epigenetic inheritance



Ciliary row pattern in Tetrahymena
(http://www.bioone.org/na101/home/literatum/publisher/bioone/journals/content/)

Phenotypic plasticity

(PANC-1 cells express FGF-2 (red) or FGF-2 receptor (green), but not both)



Hardikar et al. (2003) PNAS 100(12): 7117–7122

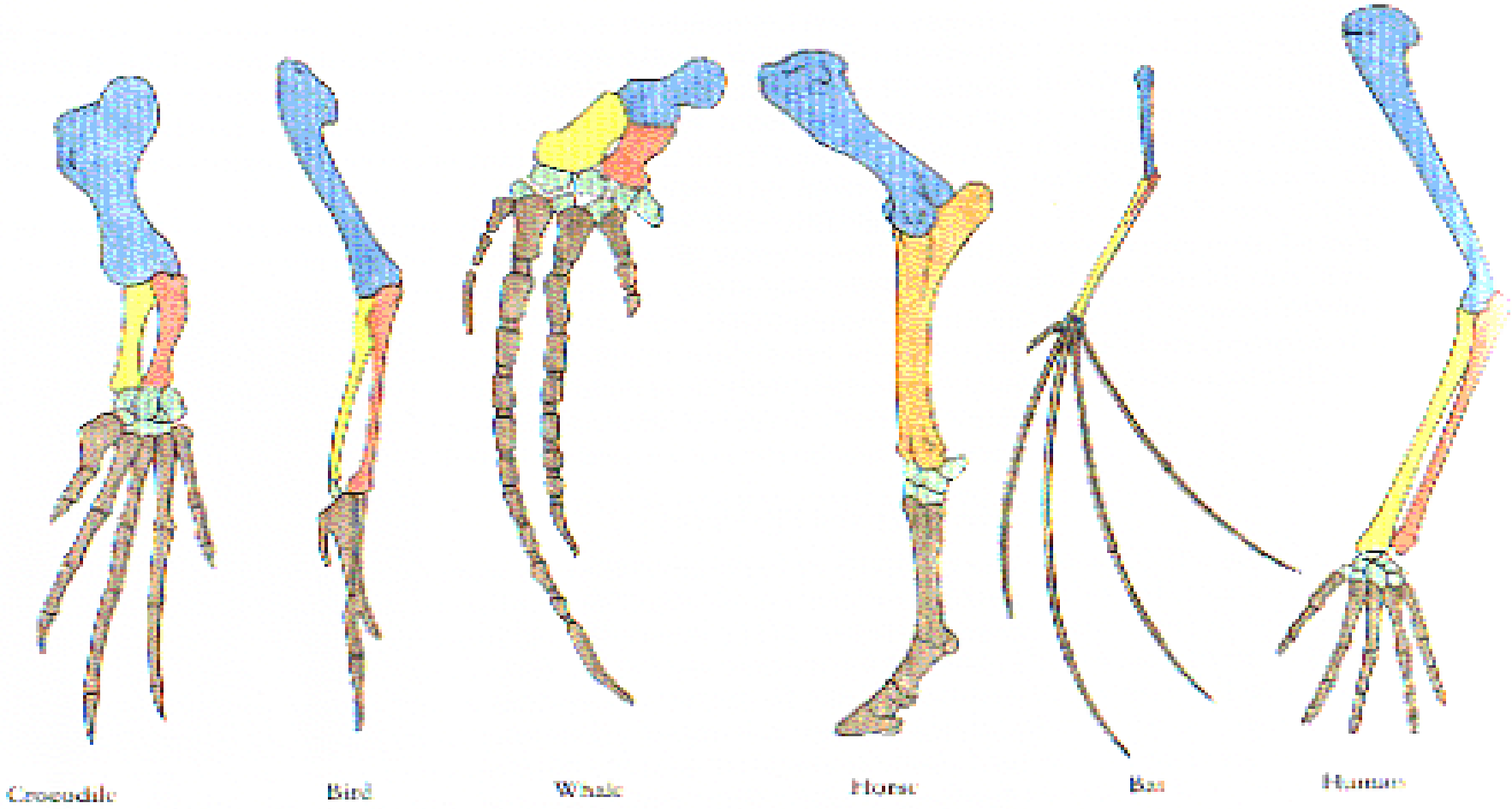
Reciprocity between organism and environment: Niche construction

snailstales.blogspot.com

Symbiosis

Egyptian plover and Nile crocodile (http://bookbuilder.cast.org/bookresources/12/12710/46346_1.jpg)

Developmental constraints: self-organisation?



http://home.comcast.net/~mkent595/circum1.gif

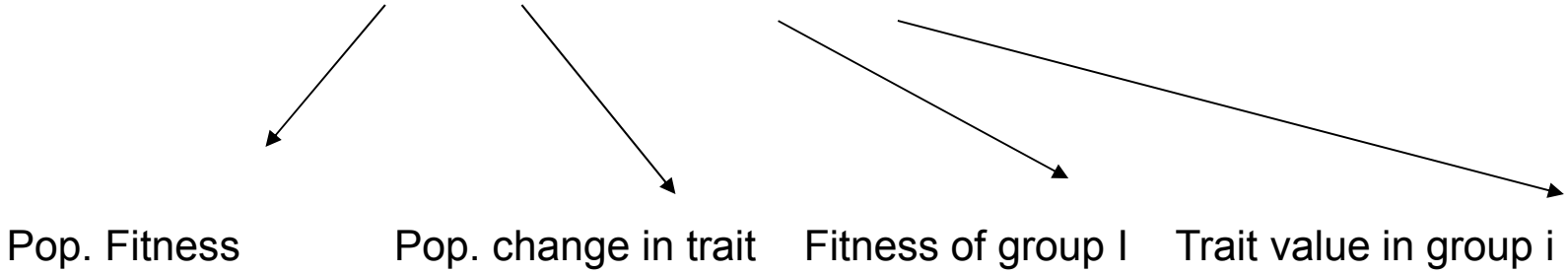
‘Altruistic’ behaviour

Meerkat

The Price formalism

Between-group effects [cov (w_i, z_i)] distinguished from within-group [mean (w_i Δz_i)] effects

$$\mathbf{w.\ \Delta z = cov\ (w_i,\ z_i) + mean\ (w_i\ \Delta z_i)}$$



Crucial point: covariance between group fitness and trait value.

IF the second term on the right is <0,

can the first make up and yield an overall positive value for ***Δz*** *?*

First suggestion of possible necessary condition.

Where are we today?

1. Many sources of variation
2. Many routes to inheritance (mostly from parent to offspring, sometimes horizontally)
3. Rampant pleiotropy
4. Different routes to adaptation