Sociedad de Lógica, Metodología y Filosofía de la Ciencia

Valencia, 19 nov. 2009

Fitness Landscapes

a scientific tool,
its epistemological status,
and the quest for synthesis
in evolutionary biology

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Sewall Wright (1932)

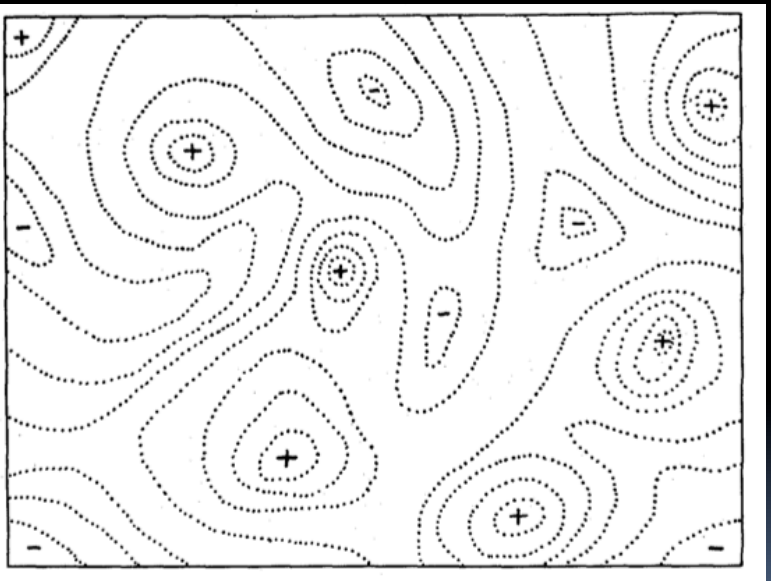
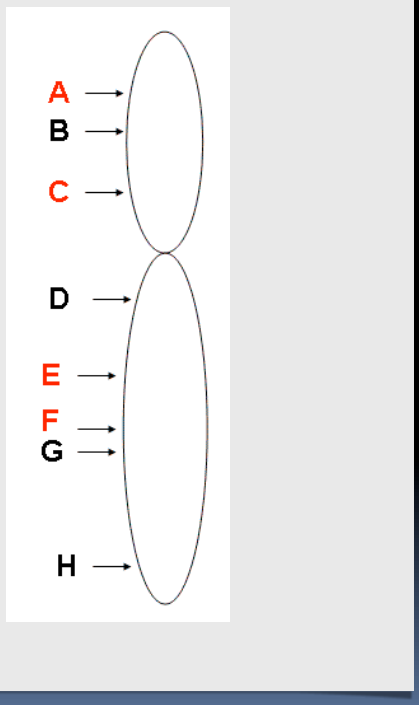


FIGURE 2.—Diagrammatic representation of the field of gene combinations in two dimensions instead of many thousands. Dotted lines represent contours with respect to adaptiveness.

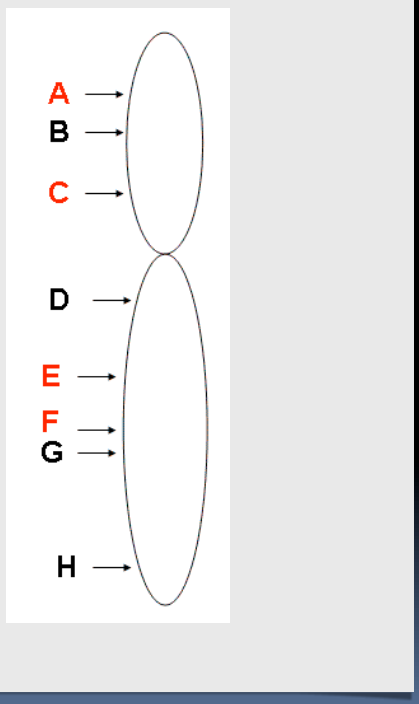
Genetic Map

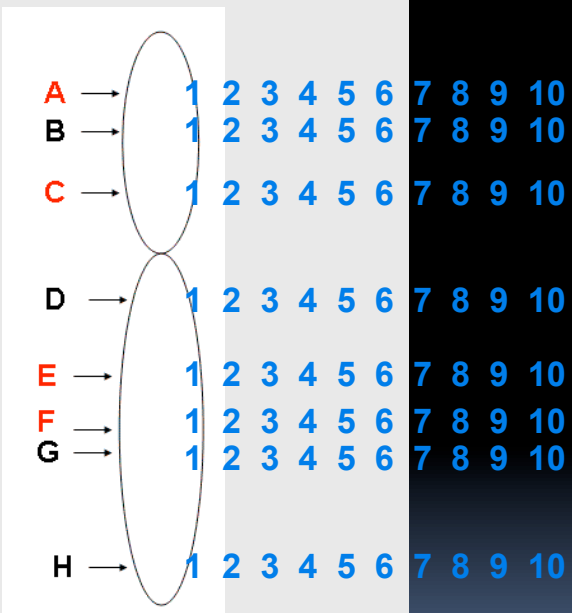
- a chromosome map of a species that shows the position of its known genes […] relative to each other
- genes can be
  - located
  - numbered
  - named
- and these are typical of a species



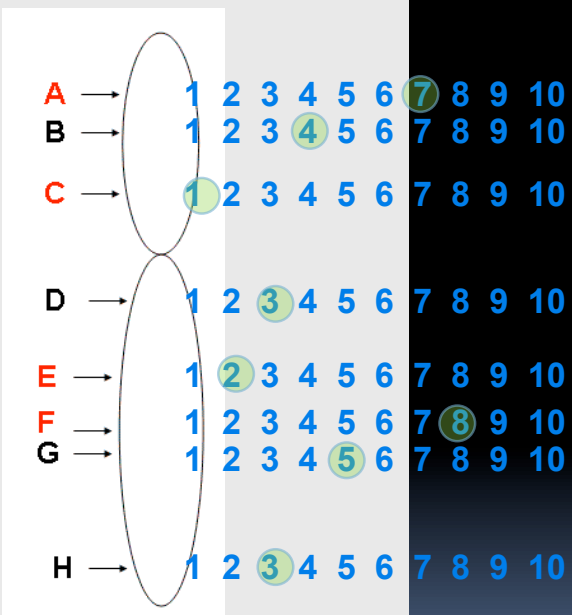
Allele

- One of the variant forms of a gene at a particular locus, or location, on a chromosome. Different alleles produce variation in inherited characteristics such as hair color or blood type.

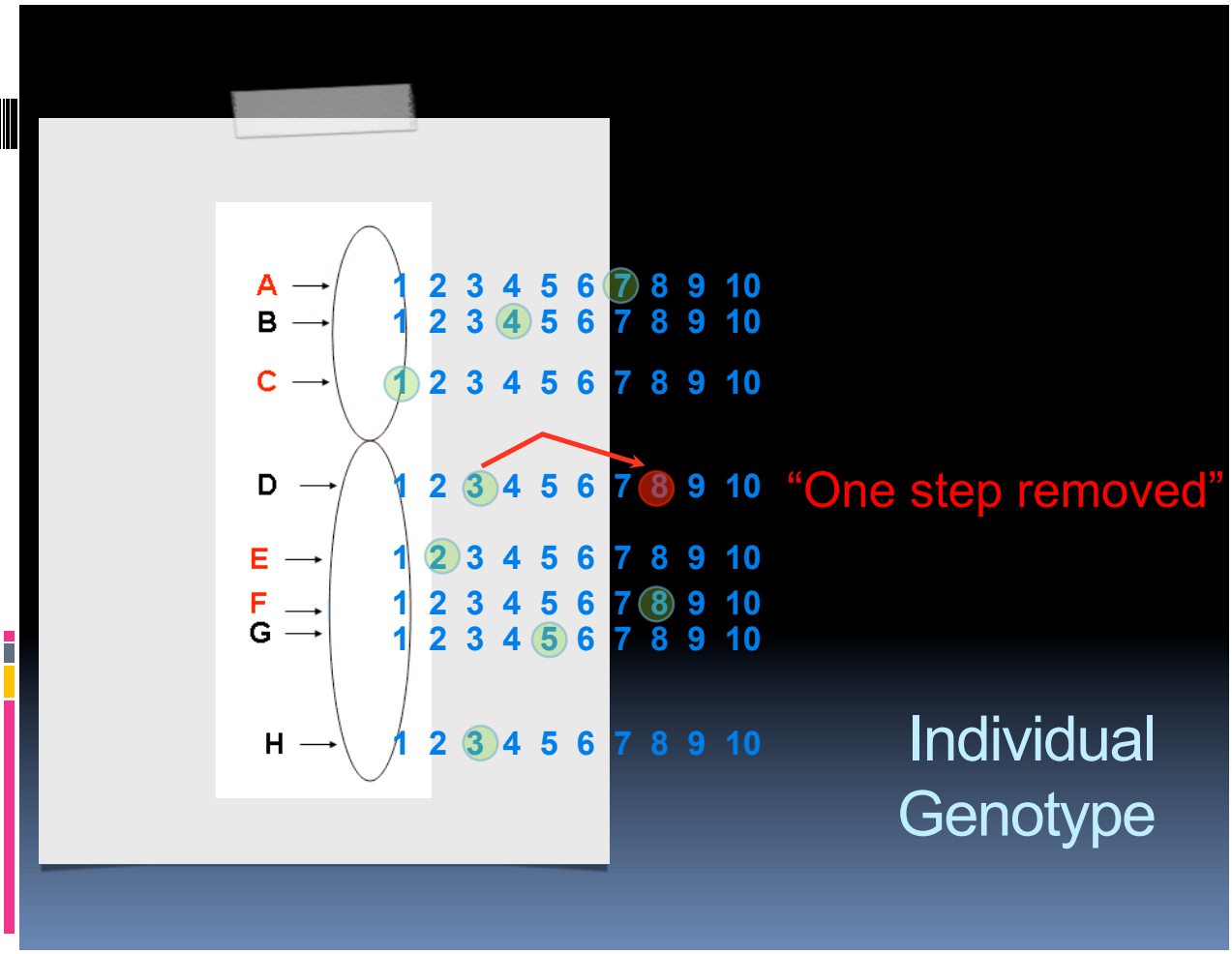


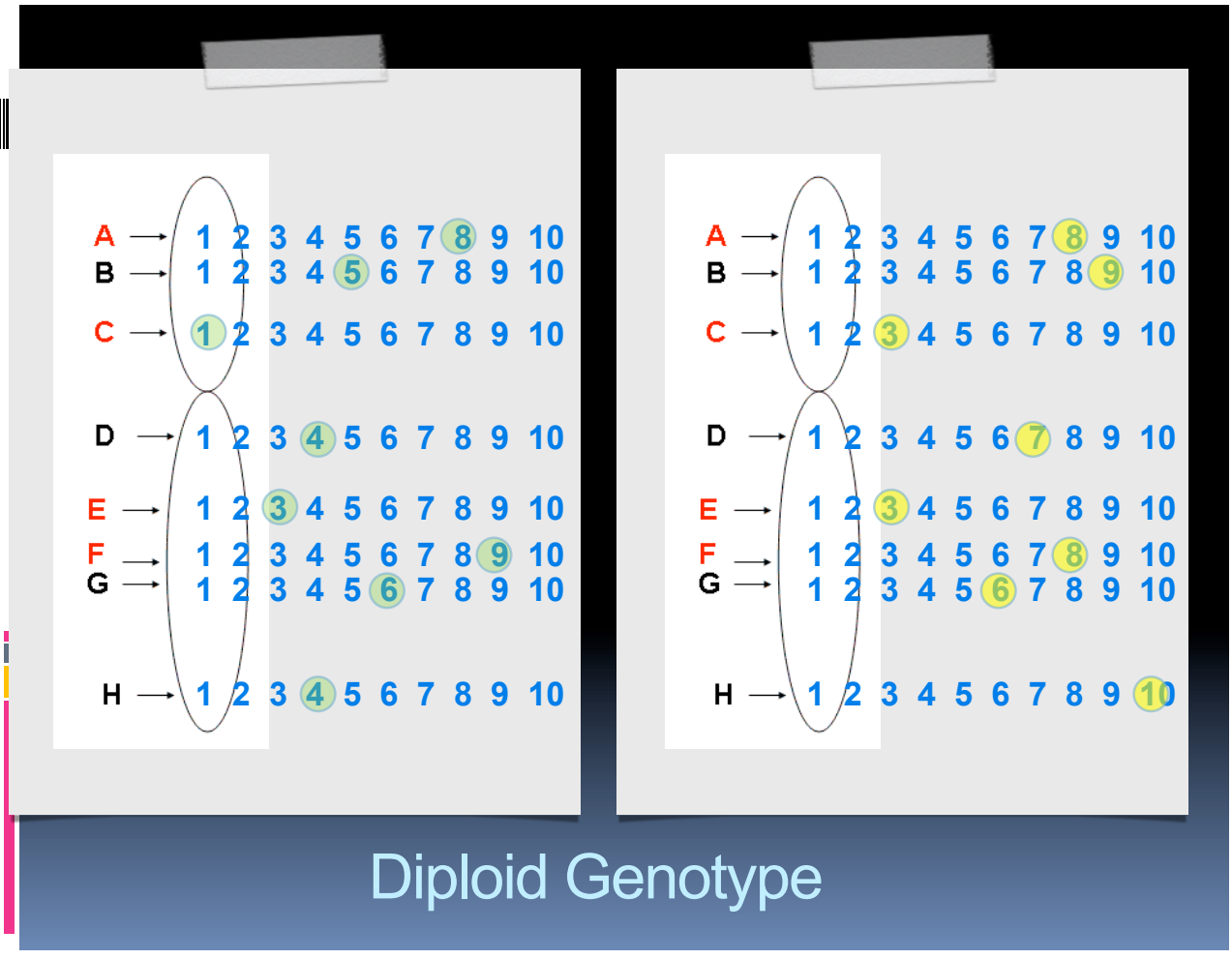


"Genotype Space" of the Population



Individual Genotype


A 1 2 3 4 5 6 7 8 9 10
B 1 2 3 4 5 6 7 8 9 10
C 1 2 3 4 5 6 7 8 9 10
D 1 2 3 4 5 6 7 8 9 10
E 1 2 3 4 5 6 7 8 9 10
F 1 2 3 4 5 6 7 8 9 10
G 1 2 3 4 5 6 7 8 9 10
H 1 2 3 4 5 6 7 8 9 10
"One step removed"
Individual Genotype


A 1 2 3 4 5 6 7 8 9 10
B 1 2 3 4 5 6 7 8 9 10
C 1 2 3 4 5 6 7 8 9 10
D 1 2 3 4 5 6 7 8 9 10
E 1 2 3 4 5 6 7 8 9 10
F 1 2 3 4 5 6 7 8 9 10
G 1 2 3 4 5 6 7 8 9 10
H 1 2 3 4 5 6 7 8 9 10
A 1 2 3 4 5 6 7 8 9 10
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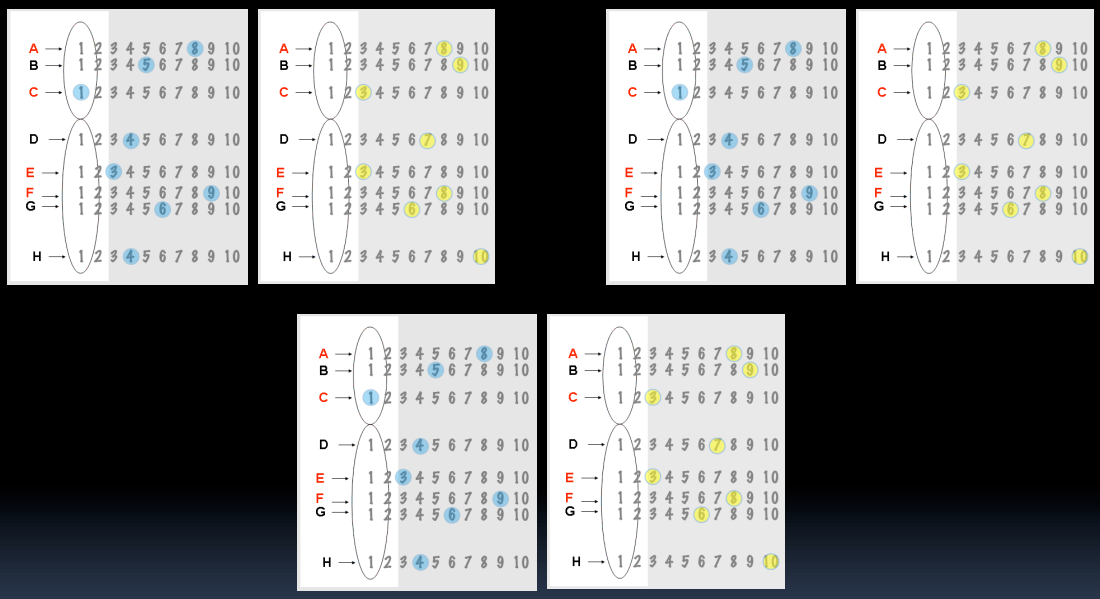
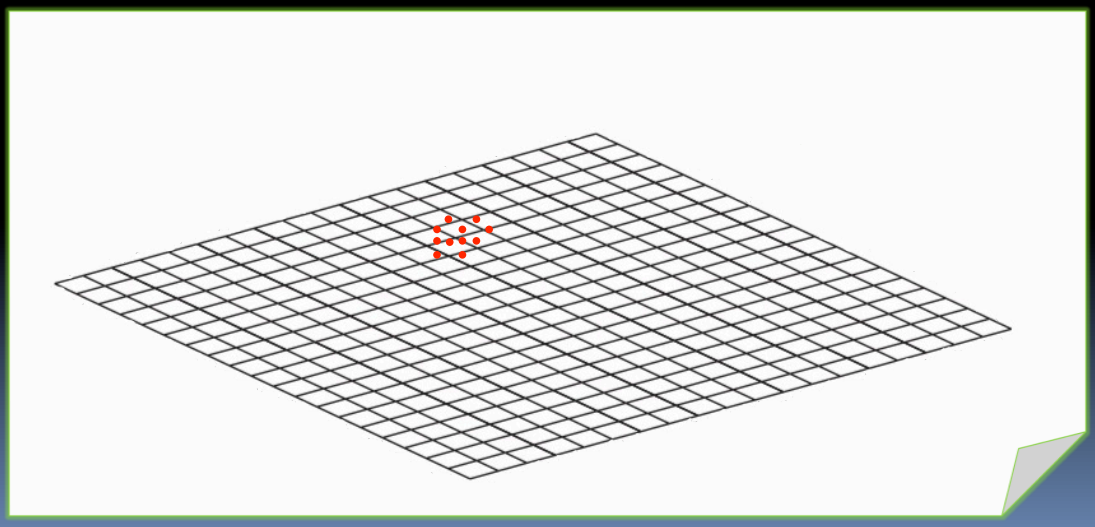
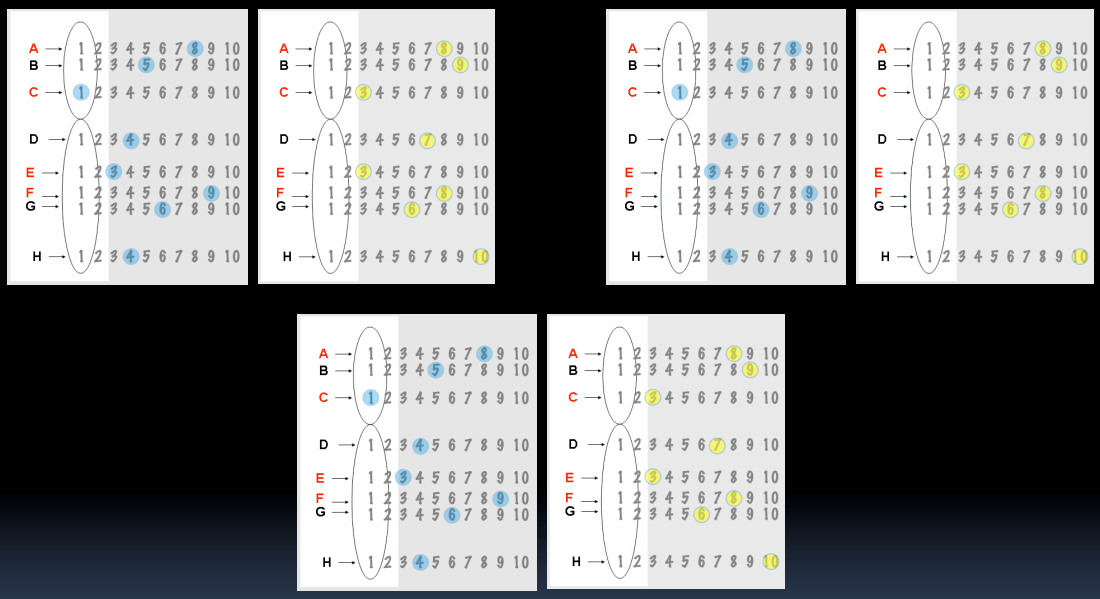
D 1 2 3 4 5 6 7 8 9 10
E 1 2 3 4 5 6 7 8 9 10
F 1 2 3 4 5 6 7 8 9 10
G 1 2 3 4 5 6 7 8 9 10
H 1 2 3 4 5 6 7 8 9 10
Diploid Genotype



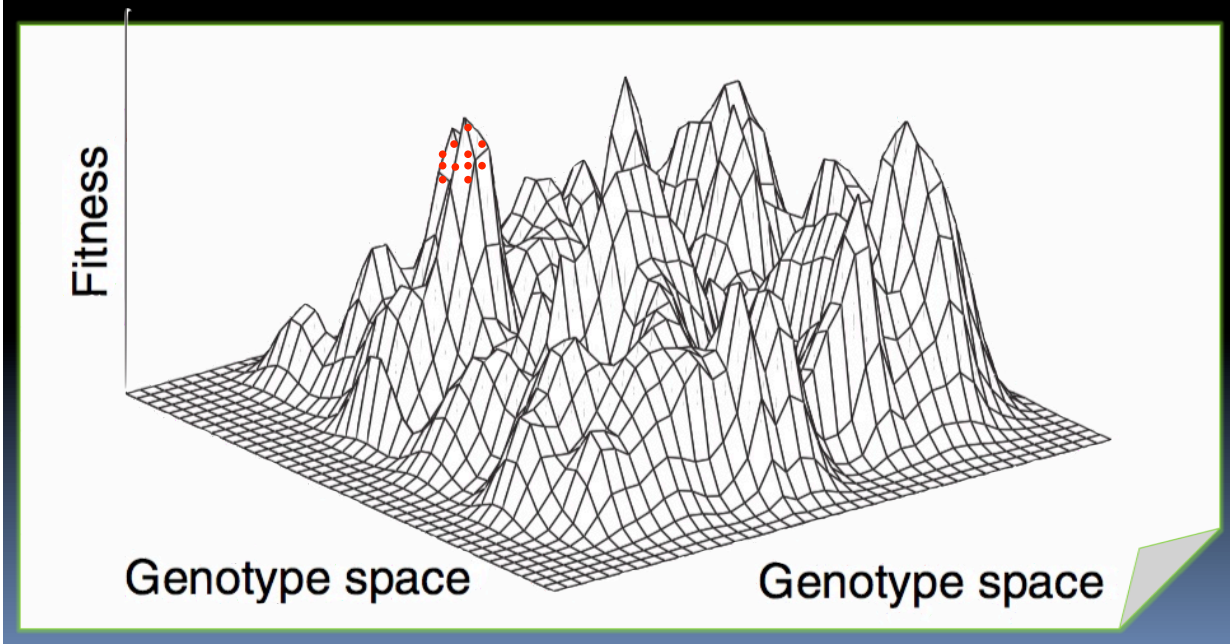
Reproduction -> Recombination





Fitness

Sewall Wright's Landscape (1932)



Sewall Wright (1932)

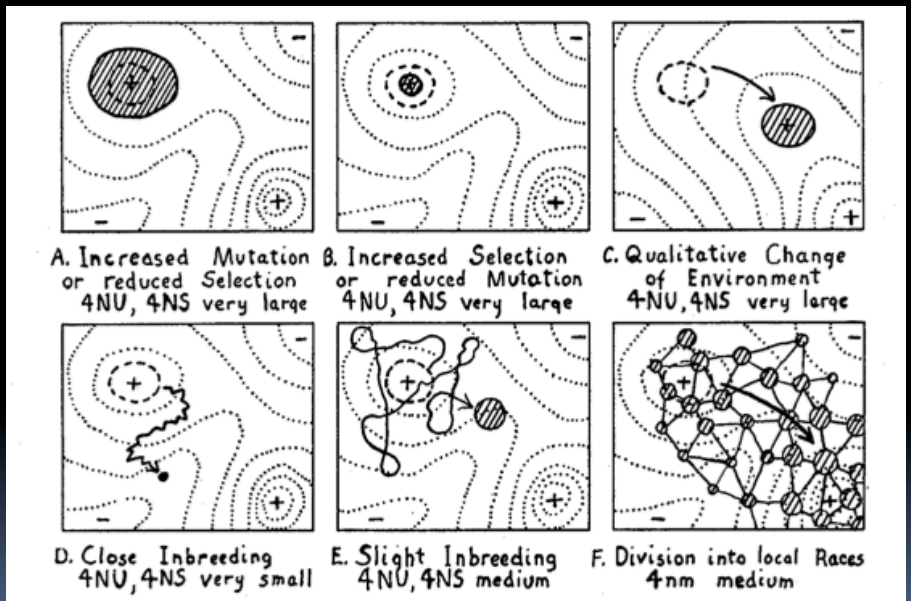


FIGURE 4.—Field of gene combinations occupied by a population within the general field of possible combinations. Type of history under specified conditions indicated by relation to initial field (heavy broken contour) and arrow.

Epistemological status

Image? (es. Kaplan 2008)

Picture?

Pictorial representation?

Visual representation?

Idea?

Notion?

Metaphor? (Pigliucci 2008, Kaplan 2008)

Model? (Calcott 2008)

Family of models? (Calcott 2008)

- Scientific tool
  - Chart (mapping function)
  - Topographical map (Eldredge 1985)
  - Diagrammatic representation (Provine), diagram

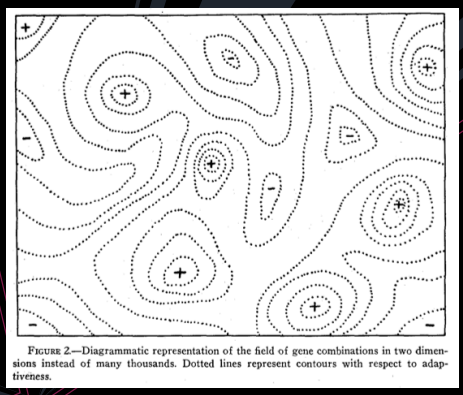


FIGURE 2.—Diagrammatic representation of the field of gene combinations in two dimensions instead of many thousands. Dotted lines represent contours with respect to adaptiveness.

Change in the scientific context

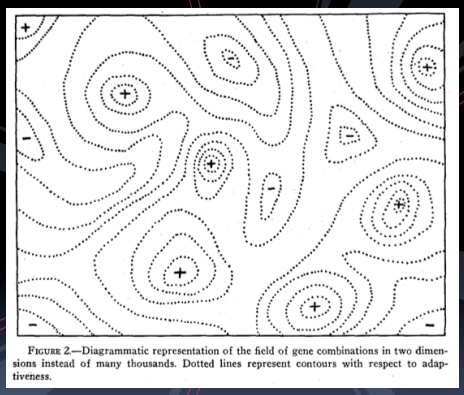
Ex. Known number of genes is of higher order

Ex. Frequency of mutations

Ex. Phenotypic landscapes

Ex. Macroevolution

Ex. Neutralism



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Sergey Gavrilets's Holey Landscape (1997)

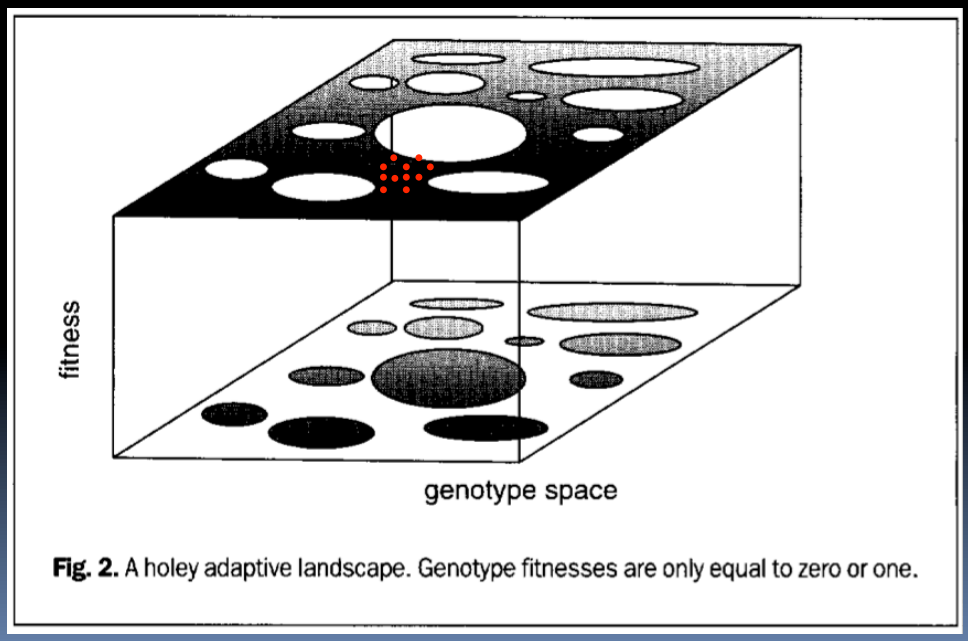

Fig. 2. A holey adaptive landscape. Genotype fitnesses are only equal to zero or one.

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The end of the adaptive landscape metaphor?

Jonathan Kaplan

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Abstract The concepts of adaptive/fitness landscapes and adaptive peaks are a central part of much of contemporary evolutionary biology; the concepts are introduced in introductory texts, developed in more detail in graduate-level treatments, and are used extensively in papers published in the major journals in the field. The appeal of visualizing the process of evolution in terms of the movement of populations on such landscapes is very strong; as one becomes familiar with the metaphor, one often develops the feeling that it is possible to gain deep insights into evolution by thinking about the movement of populations on landscapes consisting of adaptive valleys and peaks. But, since Wright first introduced the metaphor in 1932, the metaphor has been the subject of persistent confusion, from equivocation over just what the features of the landscape are meant to represent to how we ought to expect the landscapes to look. Recent advances—conceptual, empirical, and computational—have pointed towards the inadequacy and indeed incoherence of the landscapes as usually pictured. I argue that attempts to reform the metaphor are misguided; it is time to give up the pictorial metaphor of the landscape entirely and rely instead on the results of formal modeling, however difficult such results are to understand in 'intuitive' terms.

Epistemological status

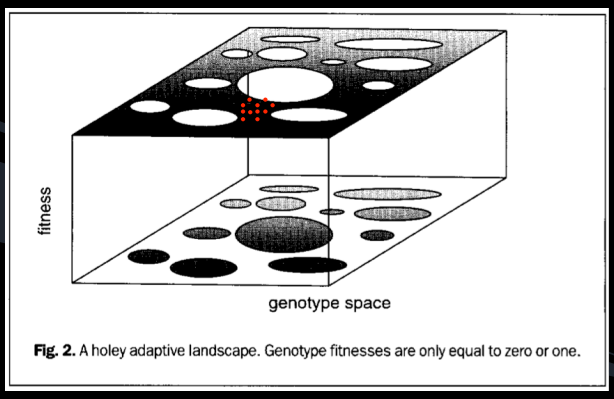

Fig. 2. A holey adaptive landscape. Genotype fitnesses are only equal to zero or one.

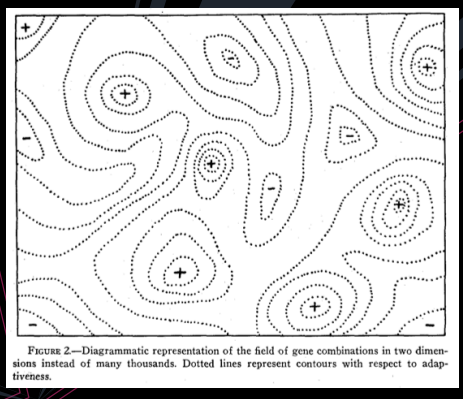

FIGURE 2.—Diagrammatic representation of the field of gene combinations in two dimensions instead of many thousands. Dotted lines represent contours with respect to adaptiveness.

…metaphors are similar to mathematical models, but «the requirements for metaphorical pictures are much less strict than for exact mathematical constructions» (Gavrilets 2004)

Represents one population	Represents a splitting population (microevolution)
1 population = a cloud of points	Cloud of points (fitness vs. adaptive landscape)
Fitness is individual relative	Viability (individual fitness is 1 or 0)
FL depends on local environment	Mostly independent from environment
Ordering by overall affinity	Overall affinity
Genotype	Genotype
Discrete	Discrete (varying density)
Pulsation movement	Wandering (neutral evolution)
Recombination of alleles	Fixed Number of Loci (restores this persistent loss)?
Mutation is deletetious and rare	Mutation?
NS + stochastic processes	Neutral evolution
Depends on demography	Depends on demography?

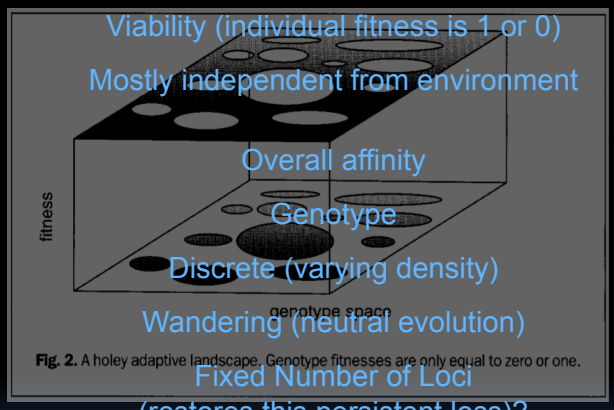

Fig. 2. A holey adaptive landscape. Genotype fitnesses are only equal to zero or one.

In common: (1) visual shape (2) vertical dimension

Changed

COMMENTARY

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DO WE NEED AN EXTENDED EVOLUTIONARY SYNTHESIS?

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Sewall Wright's adaptive landscapes: 1932 vs. 1988

Massimo Pigliucci

Given the serious conceptual issues surrounding Wright's **metaphor** of adaptive landscapes, one could reasonably ask whether it is not time to **simply drop the metaphor** altogether.

Synthesis in evolutionary biology

(a) correct identification of the *epistemological status* of scientific tools

(b) consideration of scientific tools in their proper *context of origin* and *domain of applicability*, also (even especially) in occasion of updates and revisions

(c) profiting by limits and overinterpretations concerning particular tools *as opportunities* for clarification and correction of misunderstandings, rather than as flaws and reasons for leaving that tools behind.

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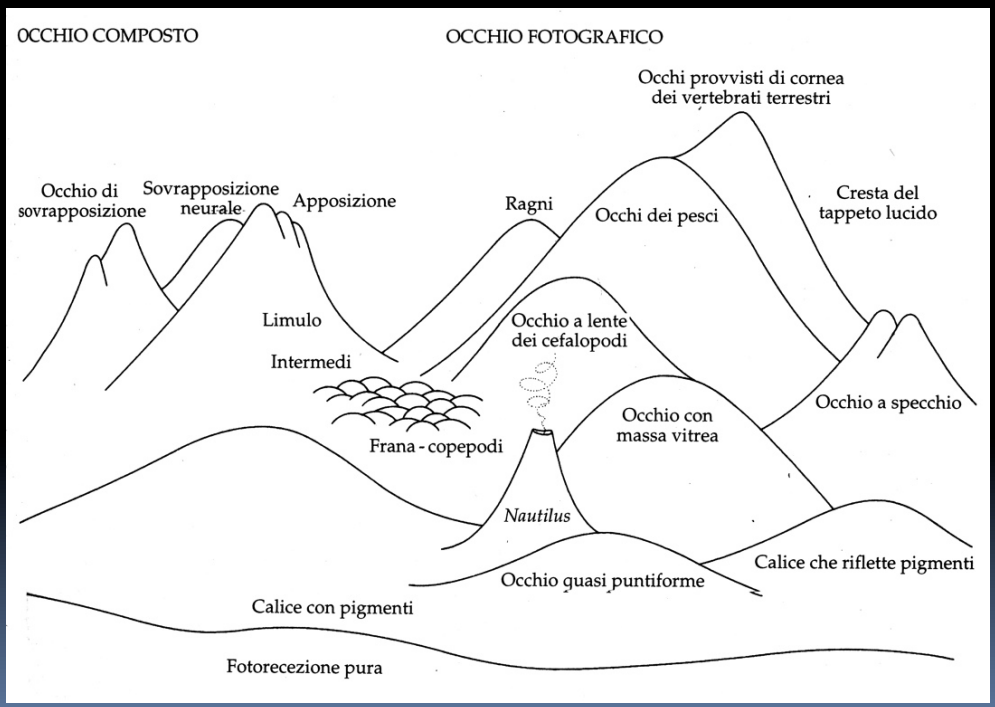
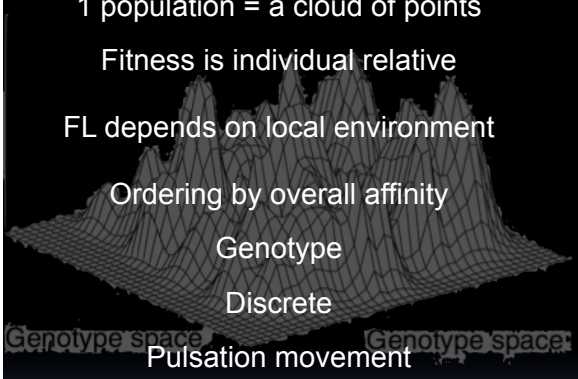
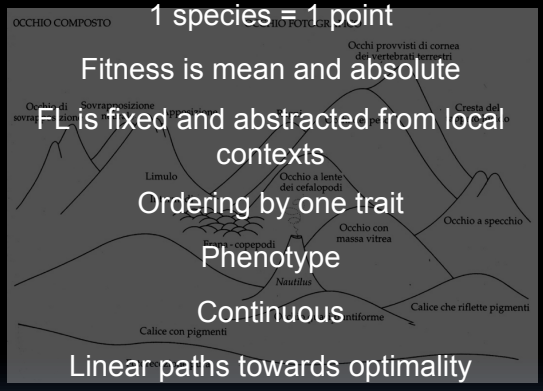
Richard Dawkins (1996)



Differences

Represents one population	Represents several species
1 population = a cloud of points	1 species = 1 point
Fitness is individual relative	Fitness is mean and absolute
FL depends on local environment	FL is fixed and abstracted from local contexts
Ordering by overall affinity	Ordering by one trait
Genotype	Phenotype
Discrete	Continuous
Pulsation movement	Linear paths towards optimality
Recombination of alleles	Mutation
Mutation is deletetious and rare	Mutation is necessary and constant
NS + stochastic processes	NS
Depends on demography	Demography irrelevant





In common: (1) visual shape (2) vertical dimension