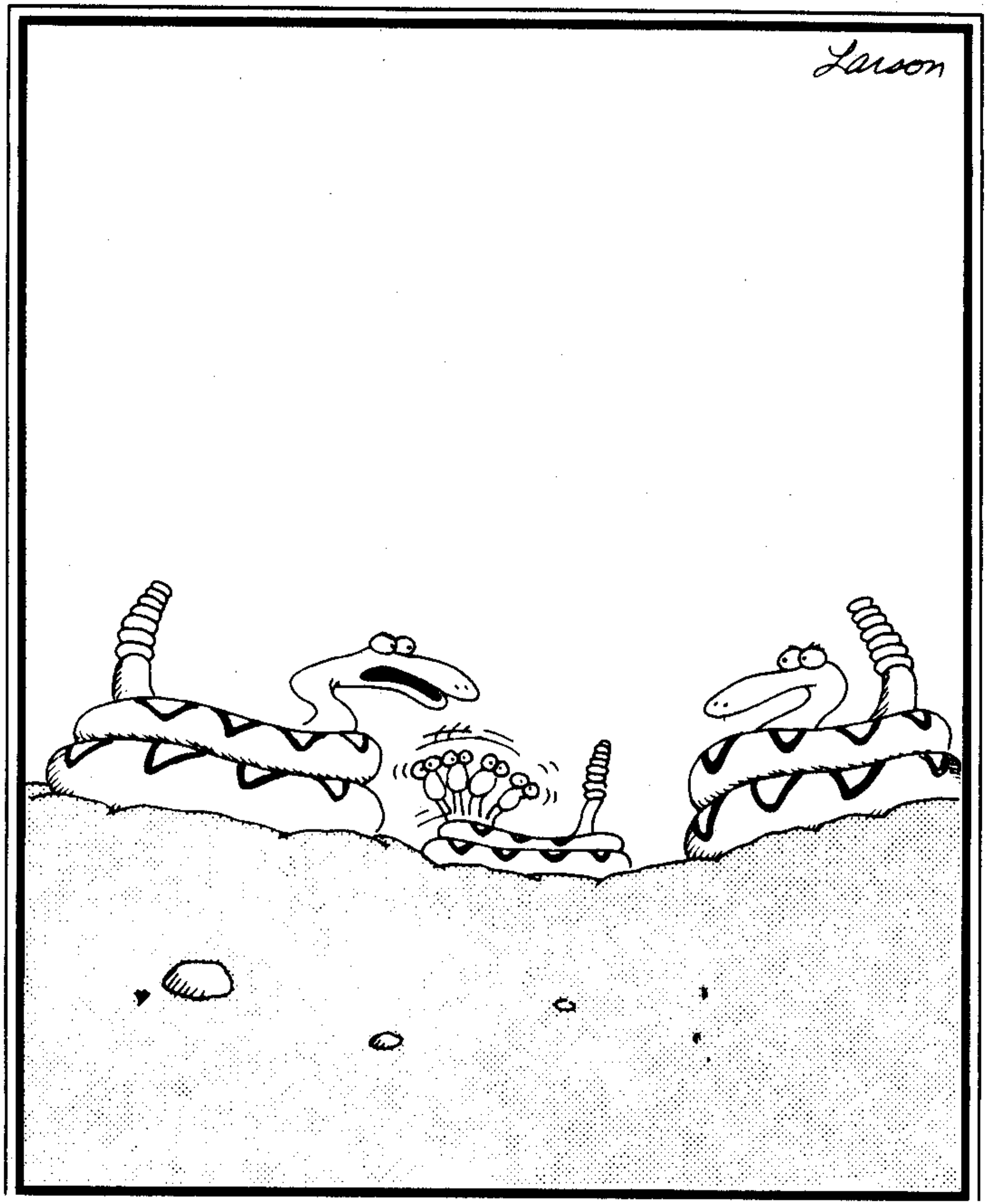
Genes and behavior



"This is your side of the family, you realize."

Genetic basis of behavior

clear genetic influence on behavior

Genetic basis of behavior

Variation is ubiquitous

- Differences between individuals in appearance, physiology, behavior…
- Variation arises due to:
  - genetic differences
  - environmental differences
- Evolution by natural selection only occurs if at least some of the variation is due to genetic differences

Genetic basis of behavior

- Challenges
  - Behaviors are complex, continuous traits
  - Many genes may underlie behavior, each with small effects (polygenic traits)
  - Lots of variability due to environmental effects

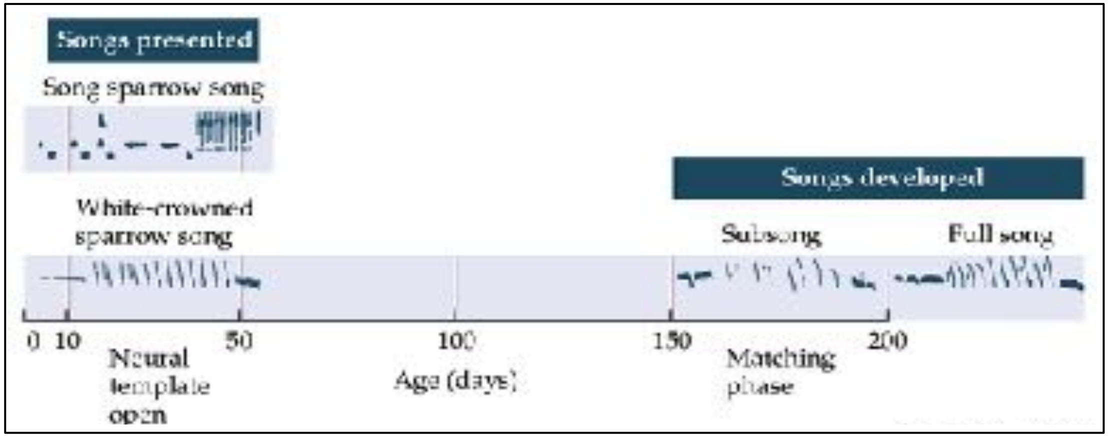
Genetic basis of behavior

- Challenges
  - Behaviors are complex, continuous traits
  - Many genes may underlie behavior, each with small effects (polygenic traits)
  - Lots of variability due to environmental effects

- What is meant by "there is a gene for behavior X"?
  - There is genetic variation underlying variation in X (there is probably environmental variation, too)
  - Genetic variation accounts for behavioral variation to some degree
  - Does not mean: Behavior X is inevitable

Genetic basis of behavior

Ex: bird song is influenced by both genes and the environment



- need to listen to other singers (environmental)
- often have innate pref for same-species songs (genetic)
- often only receptive during critical period (genetic)

For most behaviors, it is a combination of both!

Genetic basis of behavior

Traits are generally not perfectly heritable (i.e.offspring are not a perfect representation of their parents)

--this phenotypic variation could be due to genetic variation or environmental variation.

Ways to study genetic influences

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Measuring variation in alleles

- **Heritability**
  - Proportion of phenotypic variation (in a given population) due to genetic variation
  - Equation:

$$h^2 = VG/VP$$

or

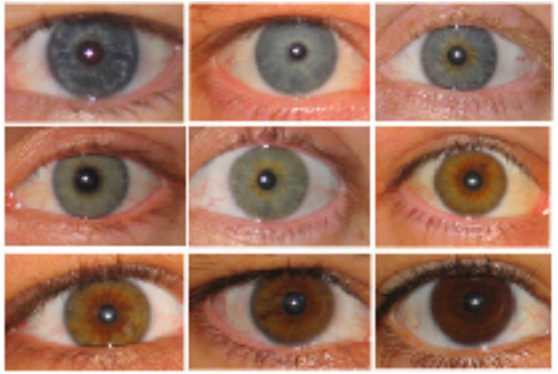
$$h^2 = VG/(VG + VE)$$

h^2 values range: 0 to 1

Measuring variation in alleles

- When h^2 LOW
  - Phenotypic variation mainly influenced by **environmental differences** (e.g., genes are fixed for 5 fingered hands, but some people loose a finger in a saw)

- When h^2 HIGH
  - Phenotypic variation mainly influenced by **genetic differences** (e.g., eye color in humans)



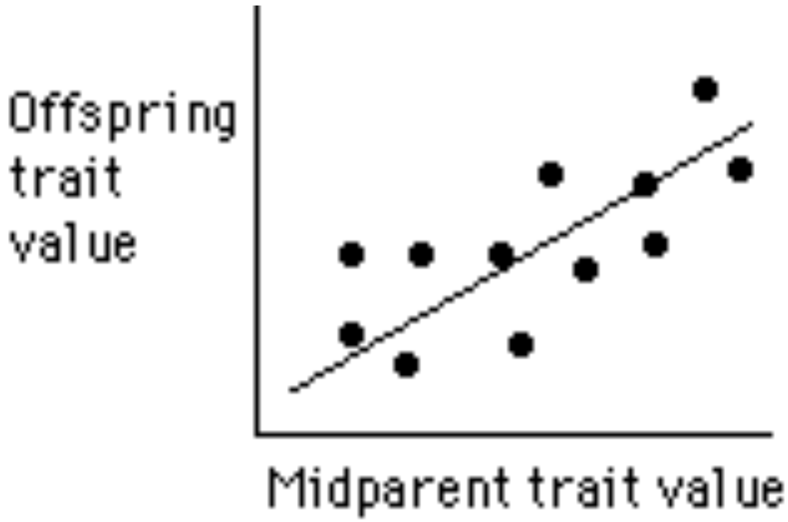
Measuring variation in alleles

Methodology:

1) Parent-offspring regression

- Plot parent-offspring regression

—slope of line = h^2



Measuring variation in alleles

Methodology:

2) Response to selection (breeder's equation)

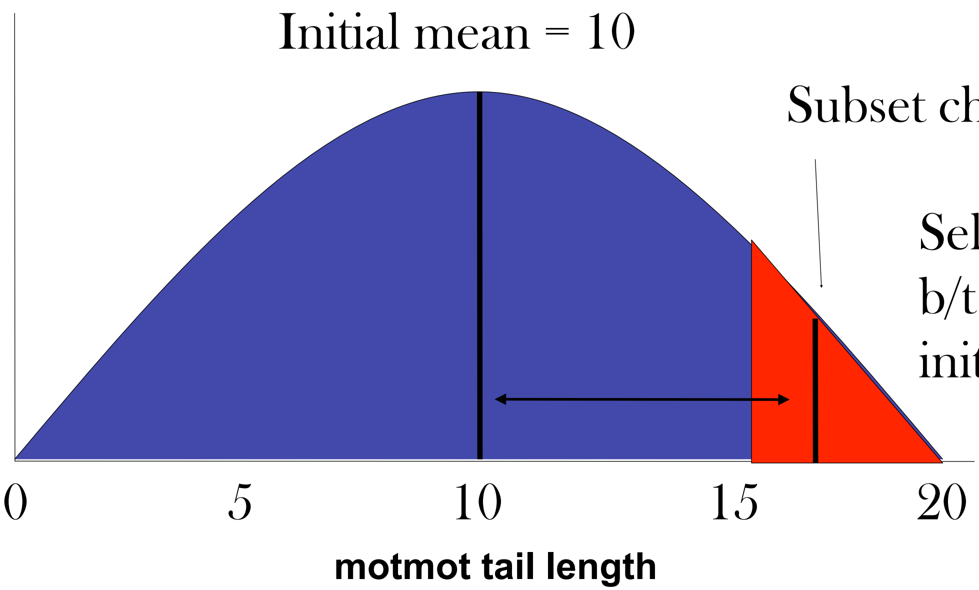
Use to assess how much shift in phenotype is possible following selection

Breeder's Equation: $h^2 = R / S$

R = Response to selection

S = Selection differential

Estimating heritability: Breeder's Equation: $h^2 = R / S$



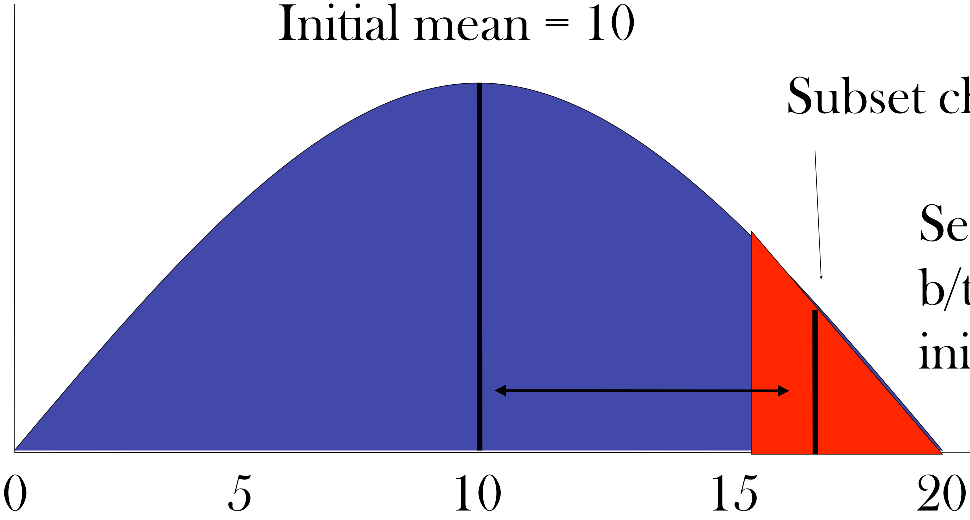
Subset chosen for breeding mean = 16

Selection differential (S): ABS difference b/t mean of selected individuals and initial mean 16-10=6

Estimating heritability: Breeder's Equation: $h^2 = R / S$

Initial mean = 10

Subset chosen for breeding mean = 16

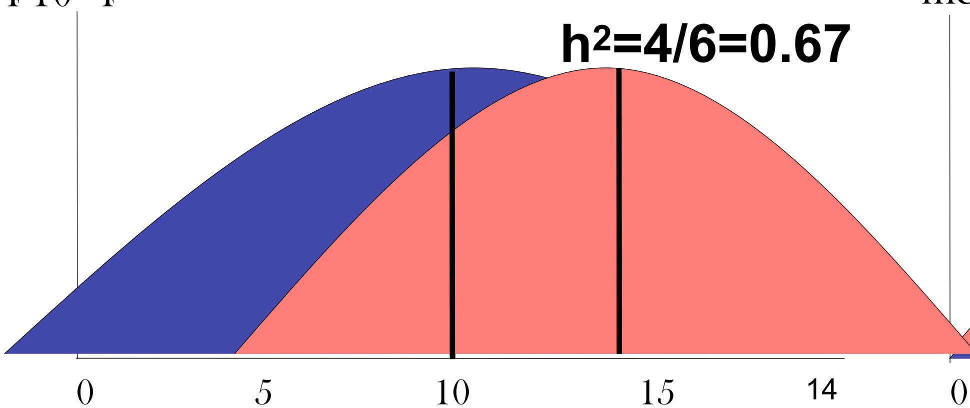


Selection differential (S): ABS difference b/t mean of selected individuals and initial mean 16-10=6

SCENARIO 1

Initial mean=10, New generation's mean=14
Response to selection (R)=ABS difference in means 14-10=4

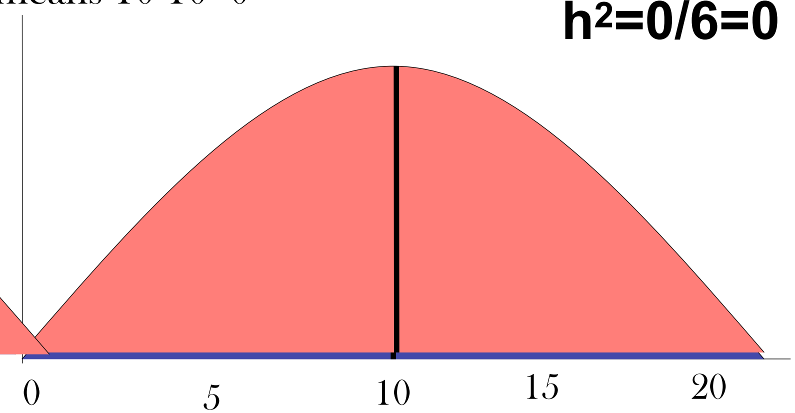
h^2=4/6=0.67



SCENARIO 2

Initial mean=10, New generation's mean=10
Response to selection (R)=ABS difference in means 10-10=0

h^2=0/6=0



Measuring variation in alleles

Example heritability values

breast stripe size $h^2 = 0.77$

# of spears $h^2 = 0.34$

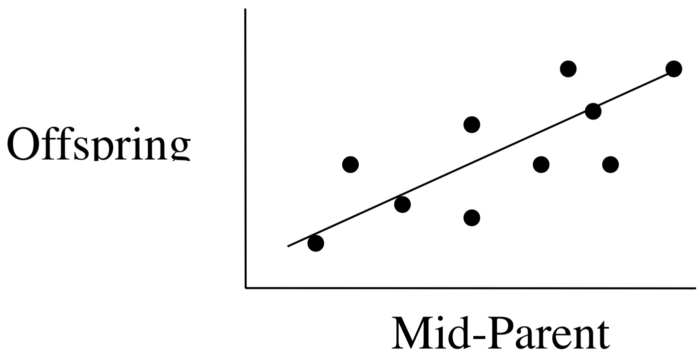
Body size $h^2 = 0.81$

Height $h^2 = 0.68 - 0.83$

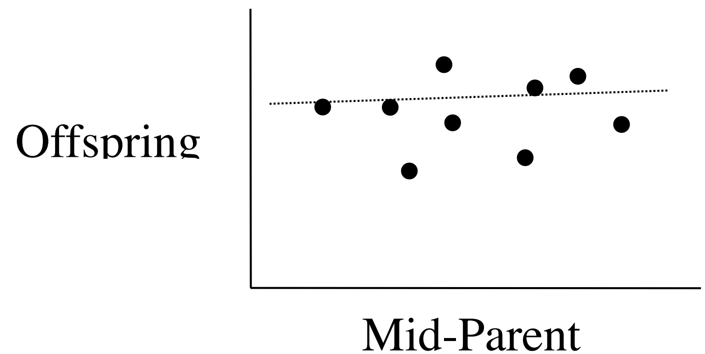
Measuring variation in alleles

Potential confusion about heritability

- h^2 is not a fixed measure. It can vary with environment:
  Exposure of kids, but not parents to sun (at beach) decreases heritability over time in the same population



WINTER: h^2=0.7
high heritability of skin color
(no one outside in sun)



SUMMER: h^2=0.2
low heritability of skin color
(only kids go to the beach)

h^2 HIGH can result from lack of variation in the environment

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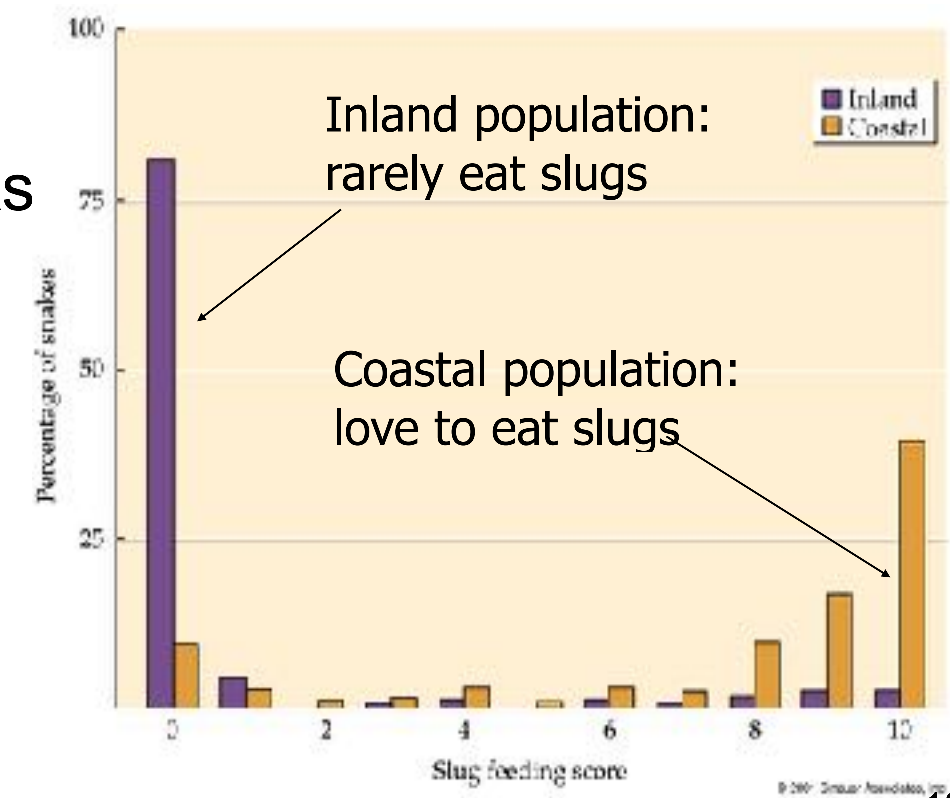
Common garden experiments

- Raise offspring (of different behavioral types) in a single environment— then measure phenotype
  - Control for possible influence of environment
  - Any variation that emerges is caused by genetic differences

- Ex: Garter snake feeding
  - Assessed by tongue flicks



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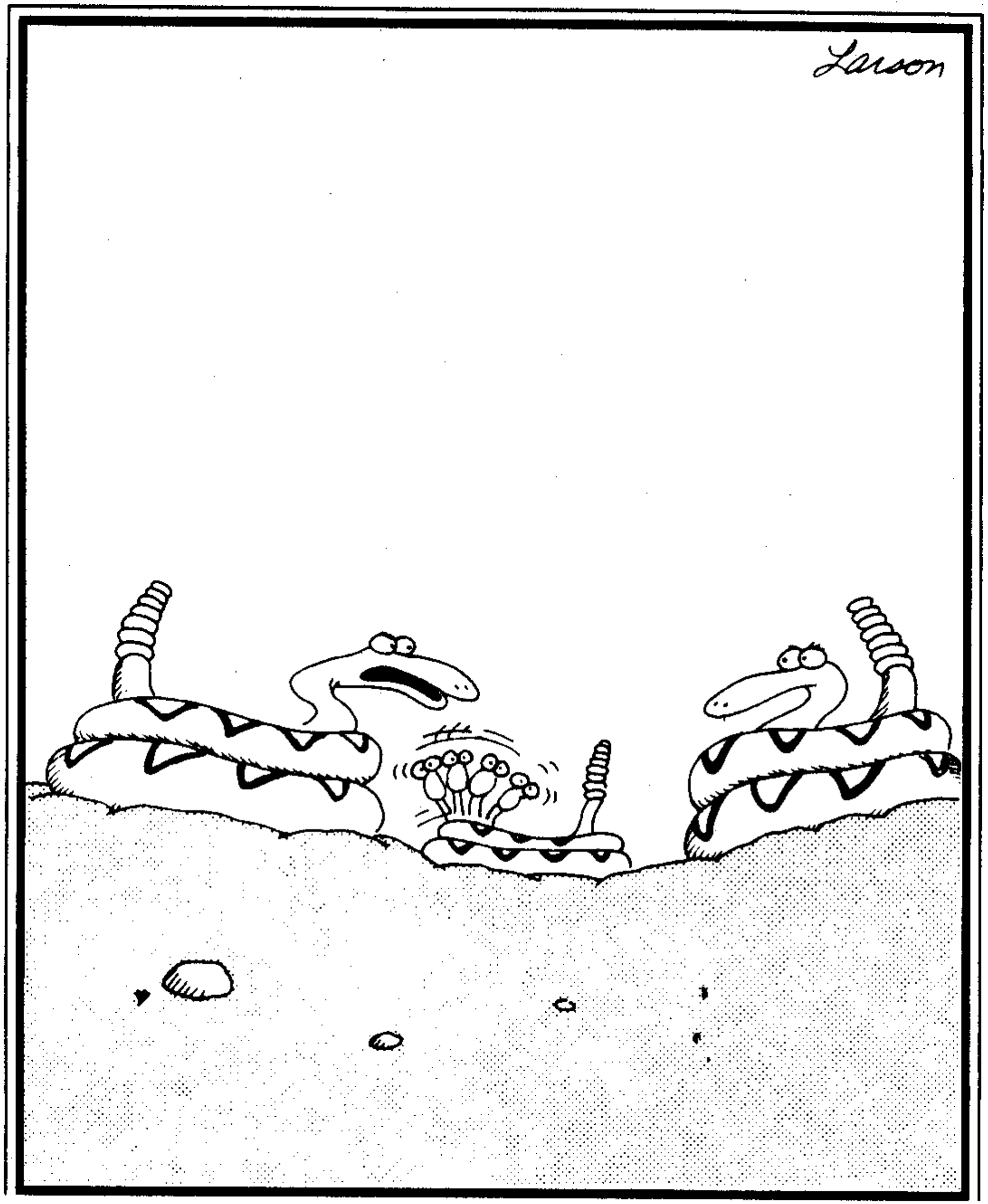

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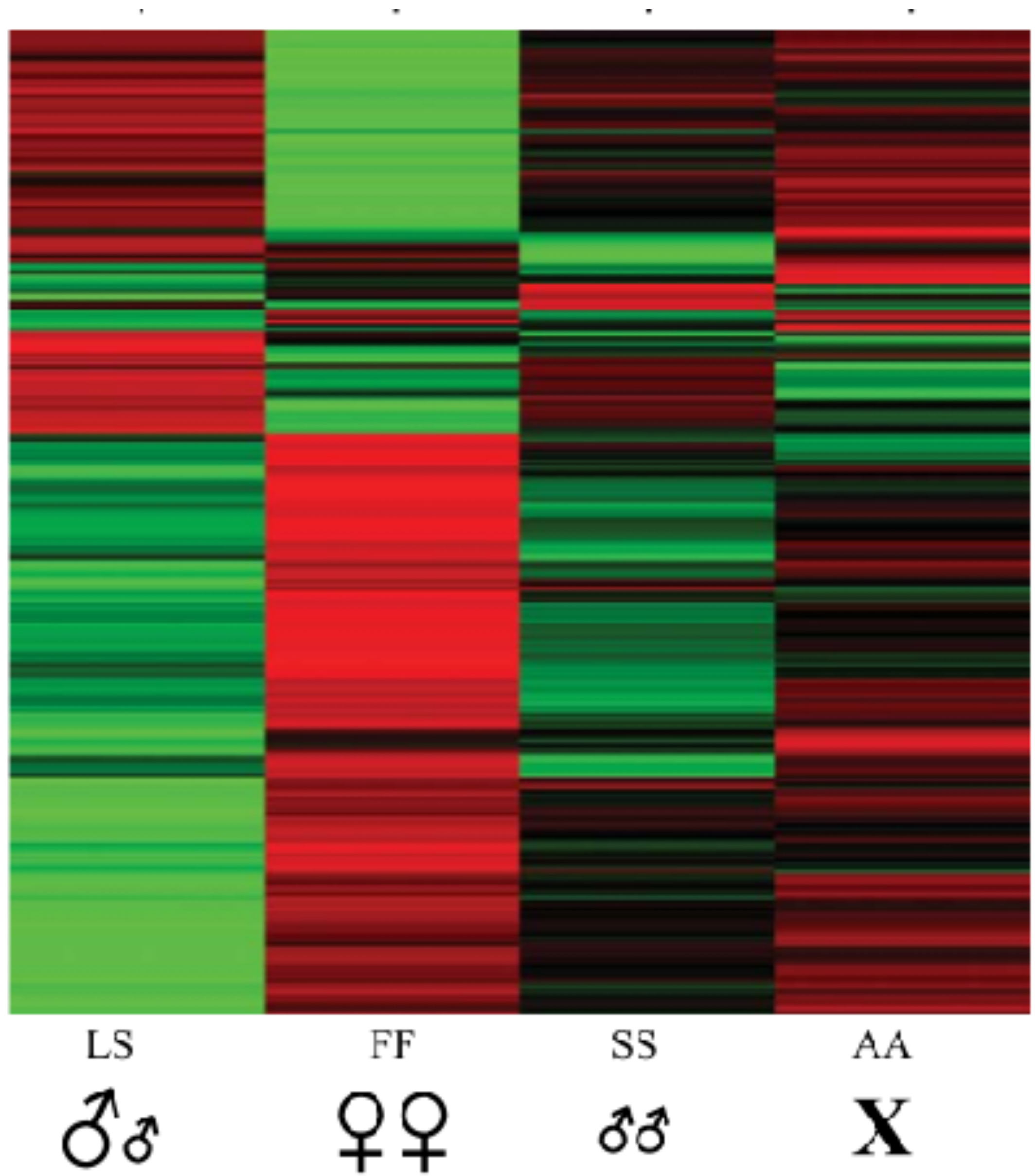
LS
FF
SS
AA
♂♂
♀♀
♂♂
X

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General breeding studies

- Different populations have different migration routes
- In 1950, blackcaps started showing up in Britain in winter

Blackcap Warbler

- Question & Hypotheses:
  - Where did these Brit birds come from?
    - H1: blackcaps breeding in Britain lost propensity to migrate south
    - H2: blackcaps arrived from another population

General breeding studies

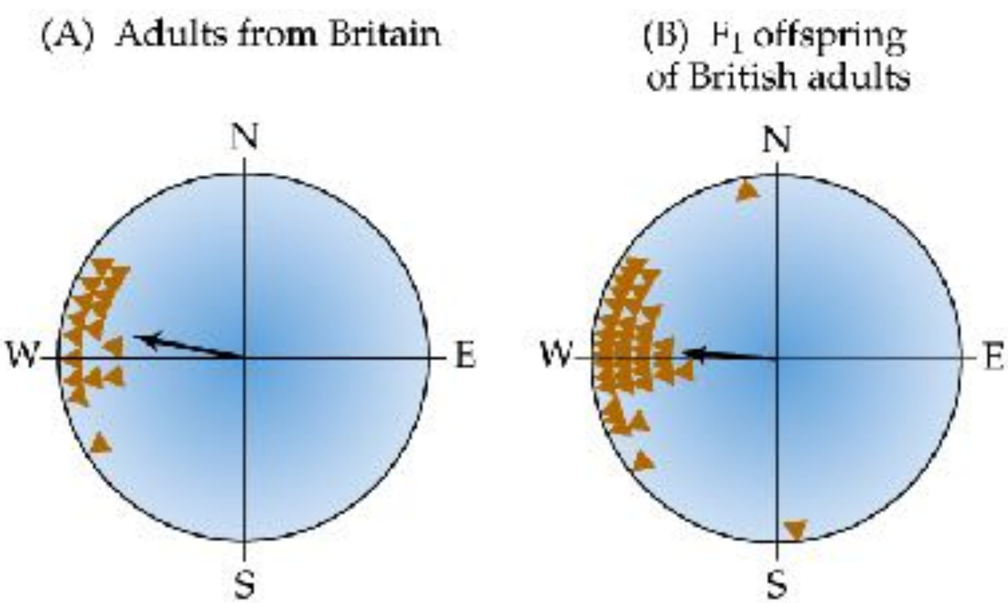
- Bird migration easier to study than you might think
- Use Emlen funnels
  - Migratory restlessness (zugunruhe)
  - Ink pad on bottom, paper on sides, mesh on top
  - Bird in cage can see sky (stars)
  - Markings of paper show orientation--where bird was trying to go

warbler in Emlen funnel

General breeding studies

- Measure orientation during ‘artificial’ migratory season:
  - adults that winter in England
  - nestlings born from birds that winter in England—that had never migrated

Blackcap Warbler



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Hybridization studies

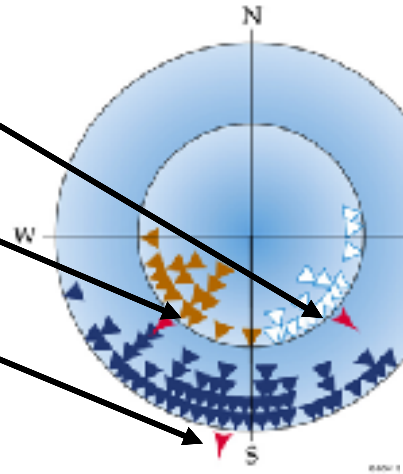
Blackcap Warbler

- Cross western and eastern migrators
  - hybrids orient south

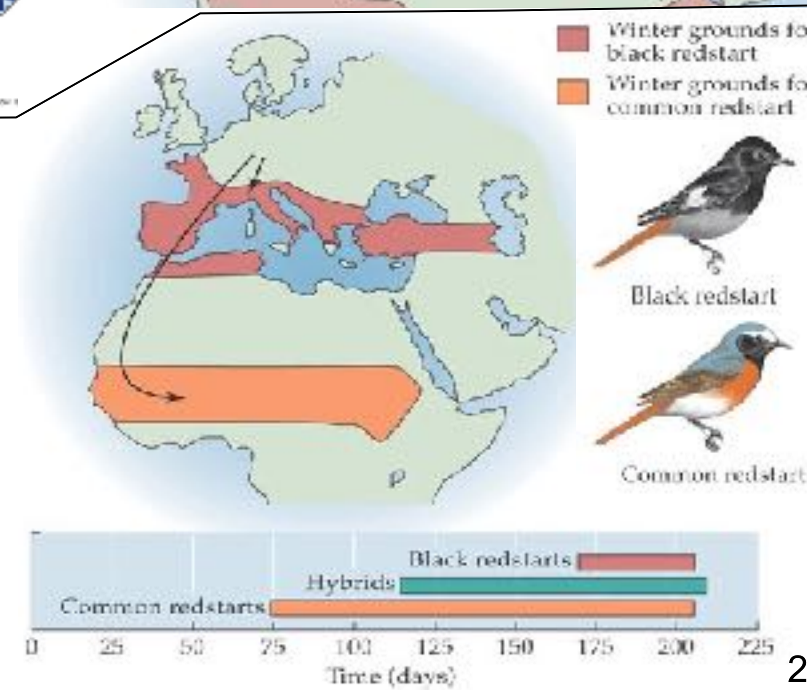
Hungarian birds

German birds

Hybrids



- Hybrids are intermediate in the timing of migration



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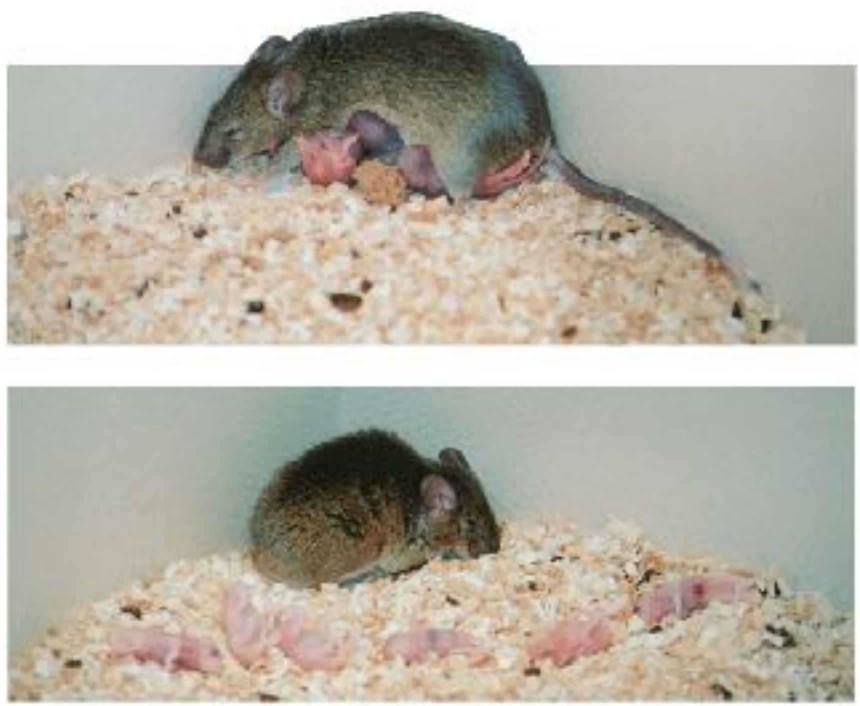
Study of behavioral mutants

- Mutation studies
  - Can artificially cause mutations, then look for an effect
  - Target particular genes, and make them non-functional
- Knockout of fosB gene in lab mice
  - Causes female indifference to kids

Wild type

Mutant



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Mutant

<u>One protein</u> leads to downstream genetic and enzymatic changes
-- and ultimately maternal behavior!

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Relatedness and "twin studies"

- Coefficient of Relatedness (r):
  - Proportion/Likelihood of shared alleles(by descent) between individuals
  - The higher the "r", the more similar individuals will be to each other (if environment are held constant)

Relatedness and "twin studies"

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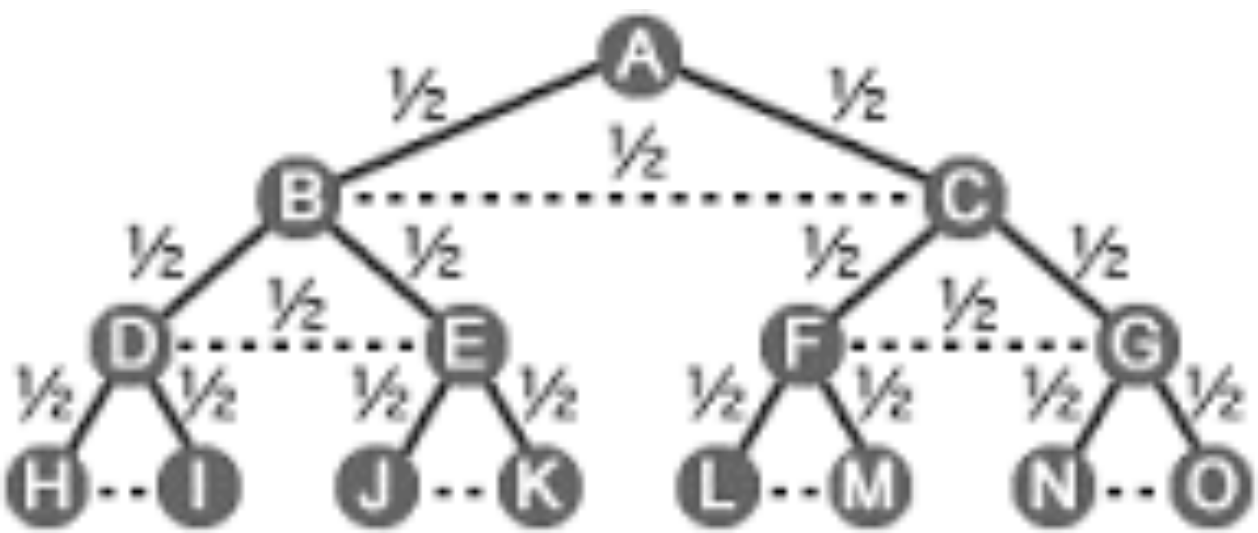


https://nbb.emory.edu/wyttenbach/gamebug/relatedness.html

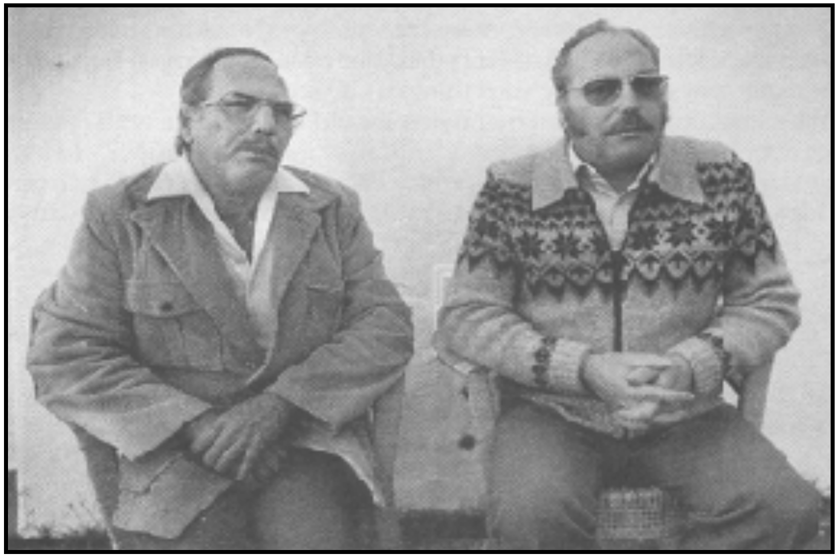
Relatedness and "twin studies"

- Different characters have different correlations:

	IDENTICAL TWINS	FRATERNAL TWINS
– Height	0.90	0.45
– IQ	0.85	0.58
– Extraversion	0.50	0.30

Relatedness and "twin studies"

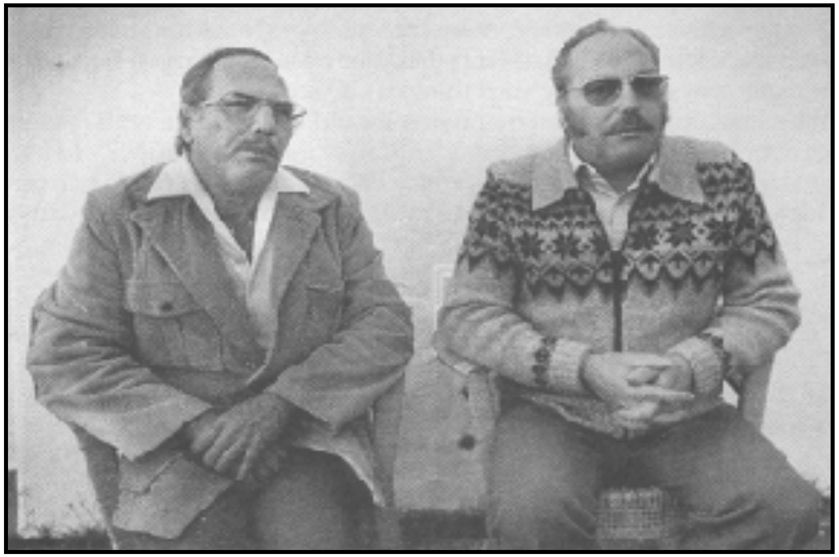
Raised in the Caribbean by Jewish father



Raised in Nazi Germany by Catholic grandmother

Relatedness and "twin studies"

Raised in the Caribbean by Jewish father



Raised in Nazi Germany by Catholic grandmother

When reunited, both: Like sweet liqueurs; Store rubber bands on their wrists; Read magazines from back to front; Dip buttered toast in their coffee; Have similar personalities

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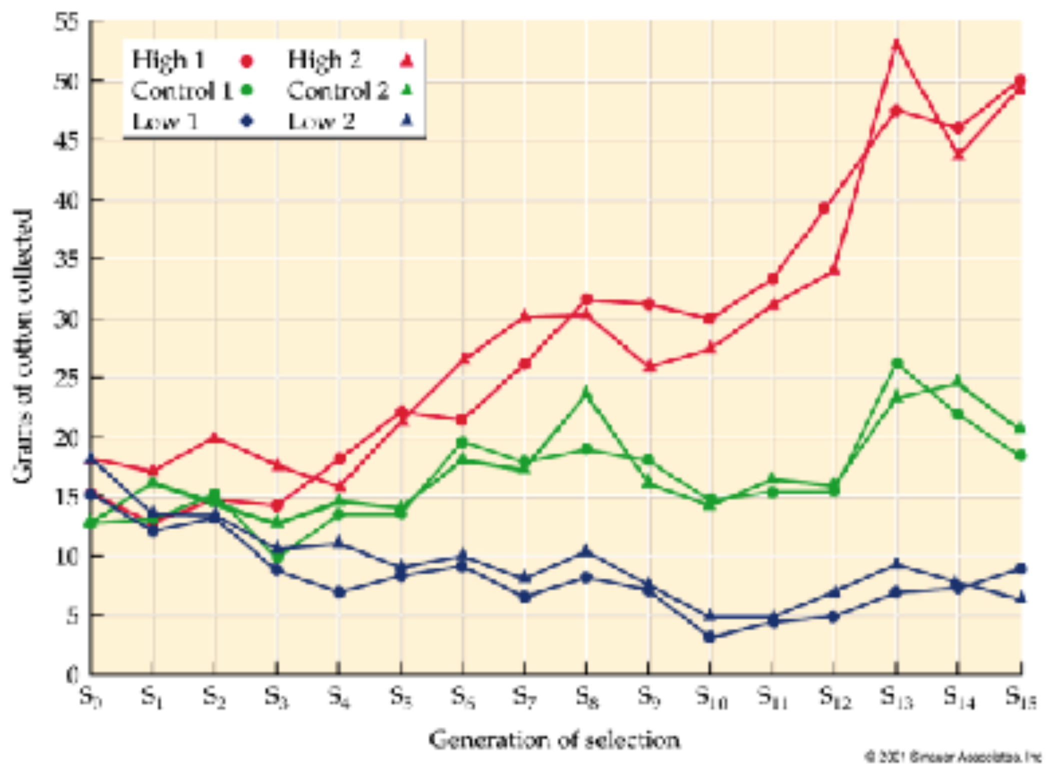
Study of artificial selection

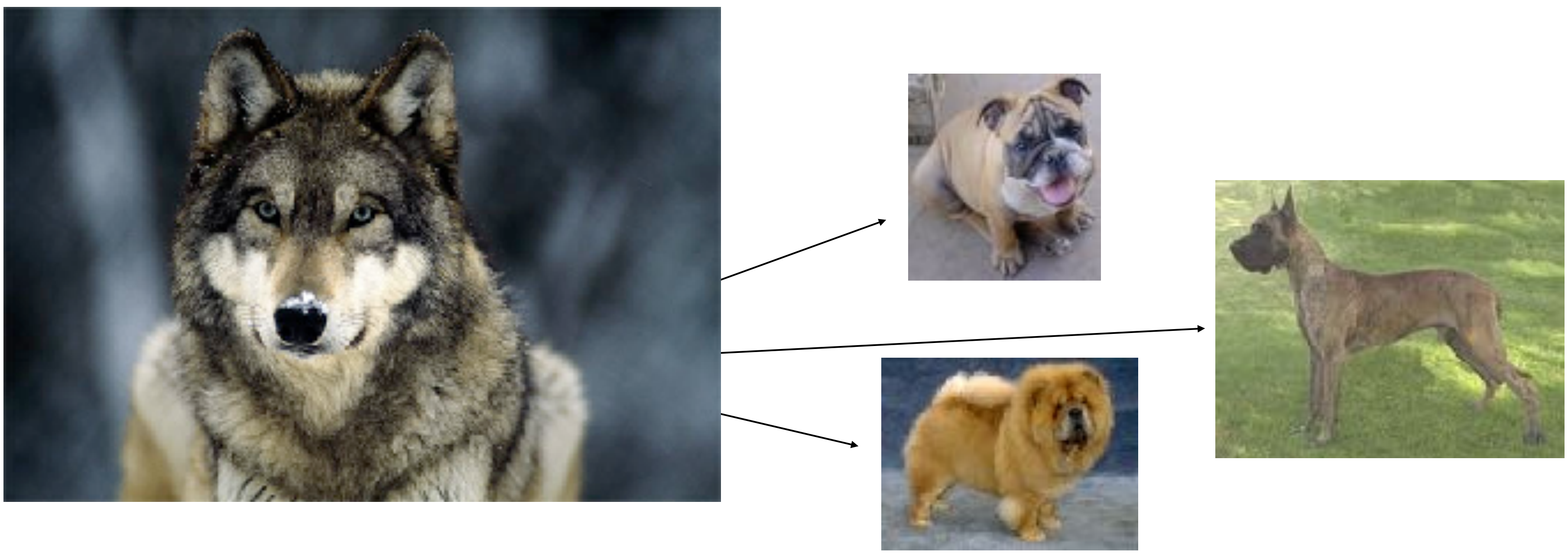
- Logic: if possible to increase expression of behavior over successive generations, there must have been a non-zero (i.e., positive value) heritability
  - Ex: nest building by house mouse

50 g cotton   5 g cotton



Study of artificial selection

- Domestication of animals
  - Wild wolves genetically similar to modern dogs
  - Selection for breeding by humans yield diverse varieties



Study of artificial selection

- Experiments with foxes
  - No "training": allow tamest foxes (top 5% ♂, top 20% ♀) to breed
  - Tameness criterion = offer food from hand; then try to pet
    - Class I: most friendly (wagging tails, whining)
    - Class II: allowed themselves to be pet, but dispassionate
    - Class III: flee from experimenter, or bite!

Study of artificial selection

- Physical traits changed
  - Loss of pigmentation, floppy ears, shorter tails, skulls smaller (less sexual dimorphism), snouts shorter and wider
- Physiological (and behavioral) traits changed
  - ↓ adrenal gland activity (less flight response)
  - ↓ corticosteroids (less stress)
  - ↑ serotonin (inhibition of aggressive behavior)
    - BIG IMPACT OF HORMONAL CHANGES
      - Retention of juvenile physical characteristics (ie neotony), and earlier/longer critical/sensitive period for imprinting and learning


Study of artificial selection

- Showed that selection for a single behavior trait – *tamability* – resulted in a suite of changes

Silver Fox

https://www.youtube.com/watch?v=HsIibD-TLcM

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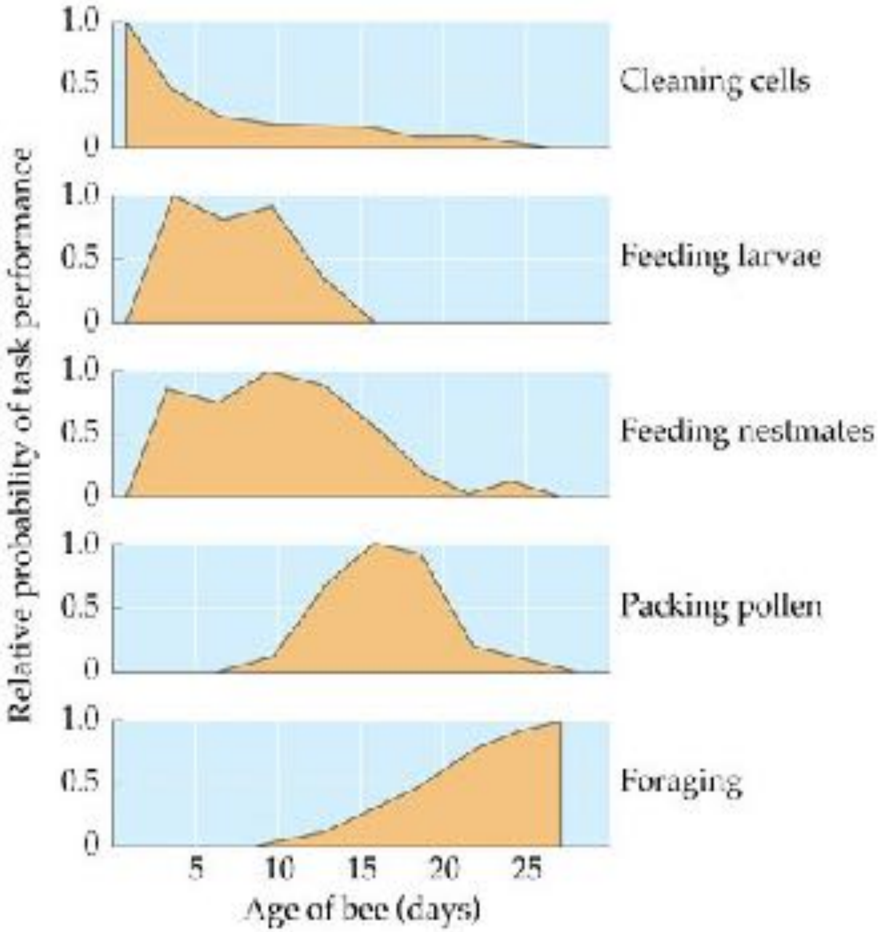
Behavioral genomics

- Using genomic approaches, we are actually able to learn how particular genes are ‘turned on/ off’ and lead to particular behaviors

Behavioral genomics

Development of worker behavior

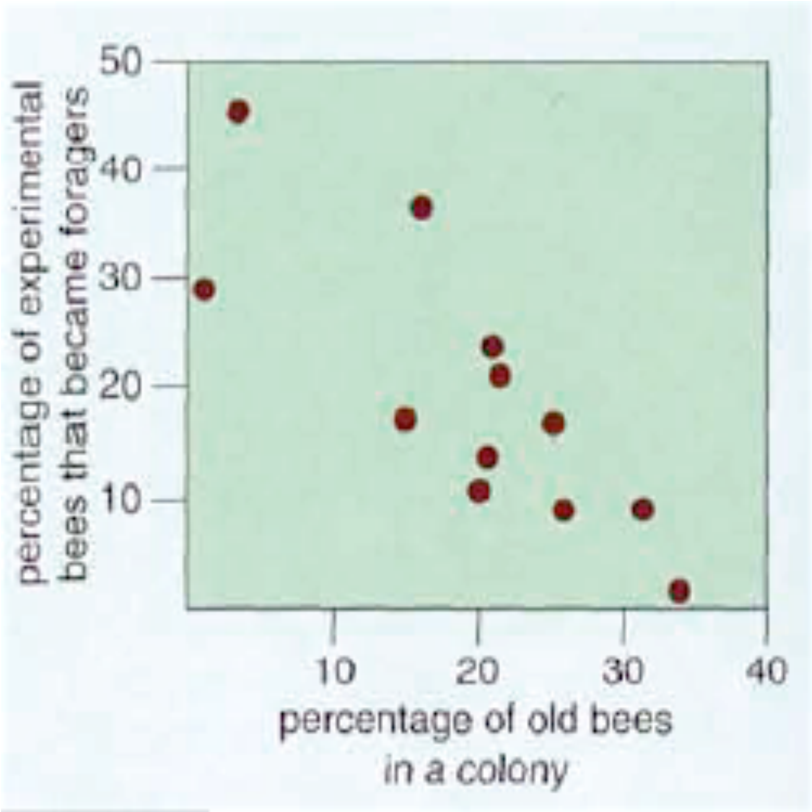
- Worker bees all have similar set of genes (r =0.75), so differences in behavior have to do with differences in <u>which genes are activated and when</u>
  - Most of this variation is in response to environmental cues



Behavioral genomics

We know: Bee development depends on environment

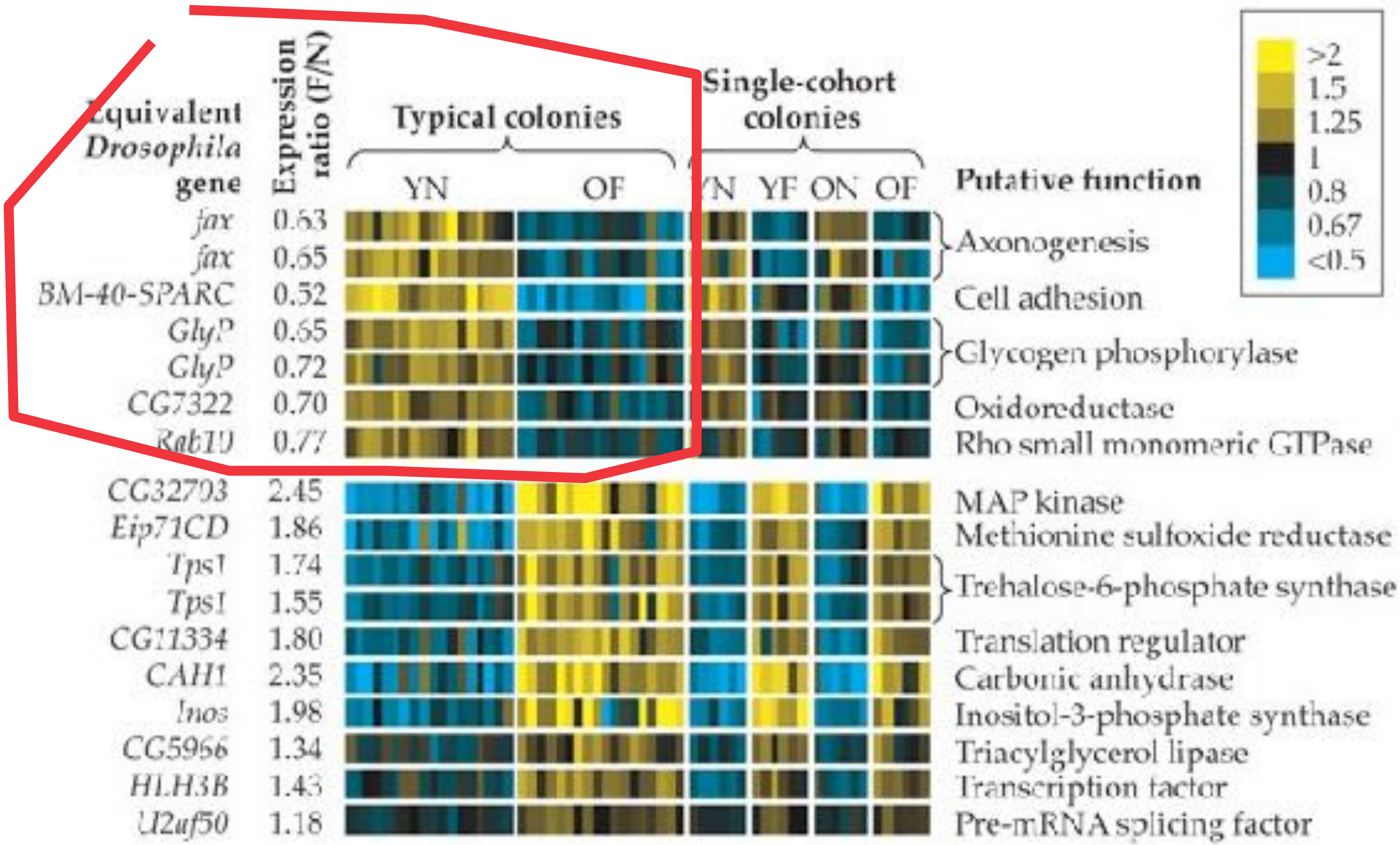
- Interactions with bees at other developmental stages regulates development
  - Regulated through mandibular gland hormones of older bees



- Researchers found that isolated young bees develop foraging behaviors more quickly than normal

Behavioral genomics

- Identification of specific genes involved in social interactions, using genomic approaches
  - Microarray analysis of different castes



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