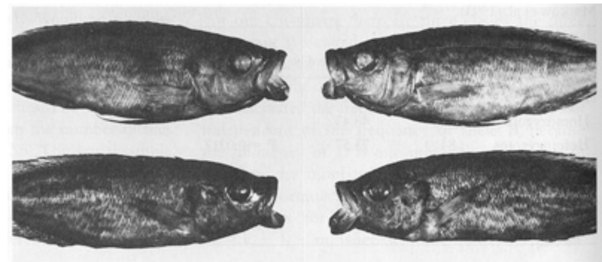
One more funny wrinkle. . .

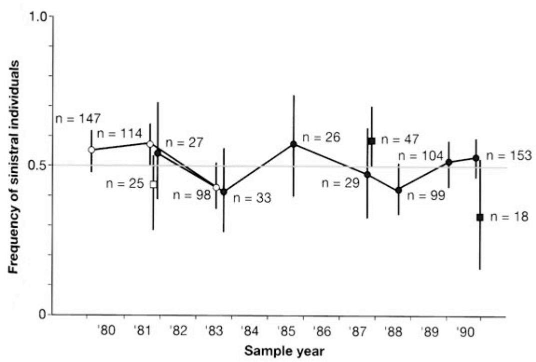
- Density-Dependent Selection
  - Fitness of a genotype is not a constant, but a function of how common (or how rare) that genotype is

Density-dependent selection in *Perissodus eccentricus*



Perissodus eccentricus is a fish native to Lake Tanganyika, Africa. It's a *lepidophagous fish,* meaning that it feeds on the scales of other fish. In order to attack more efficiently, its mouth is twisted either to the left or to the right, so it can approach from behind and to the side, grabbing a mouthful quickly. . .

It turns out that the frequencies of left-handed and right-handed variants of *Perissodus eccentricus* fluctuate from season to season. (This graph shows the frequency of "lefties" over a decade.)



Another example

- *Drosophila* larvae come in two behavioral types, *rovers* which tend to crawl long distances when feeding, and *setters* which tend to stay in one place as they feed
- This is governed by one gene with two alleles: for^R and for^s
- Work by Sokolowski et al. (1997) suggests that density-dependent selection maintains these two alleles in the population—when one is most common, the other has the selective advantage.

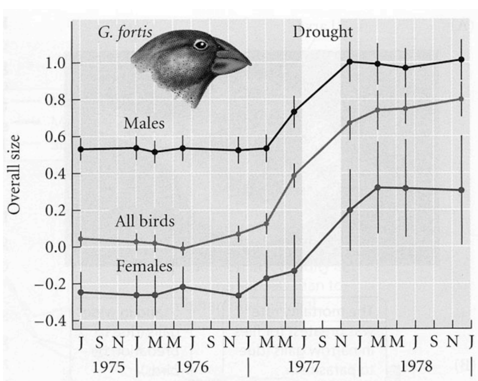
Quantitative Traits

- Quantitative traits are traits that do not have a small number of phenotypic states, but that vary continuously
  - In many organisms, traits such as height, weight, length, body part size, intelligence, etc. are continuous variables
- Quantitative traits are determined by multiple genes. . .
- . . . and also by the environment.

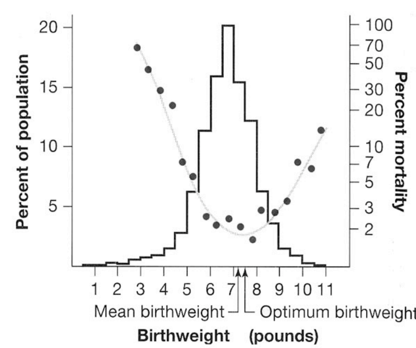
Modes of selection on quantitative traits

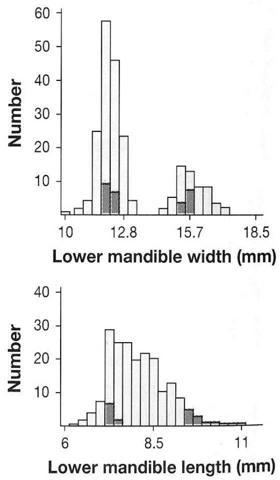
- Directional
  - Selection that tends to move the mean phenotype
- Stabilizing
  - Selection favoring mean phenotypes, acting against the extremes
- Disruptive
  - Selection favoring extreme phenotypes, acting against the mean

Directional selection in Galápagos finches: A drought in 1977 caused an increase in beak size in *Geospiza fortis*. Larger beaks can crack larger, tougher seeds.

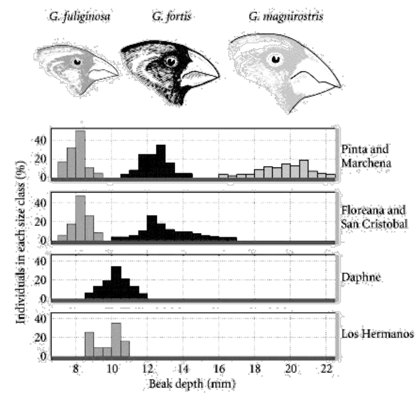


Stabilizing selection on human birthweight: Low-birthweight and high-birthweight babies are at the greatest risk of death. Since birthweight is partly heritable, stabilizing selection keeps the mean birthweight stable and close to the optimum.

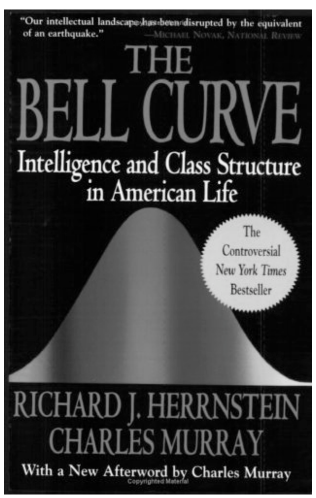




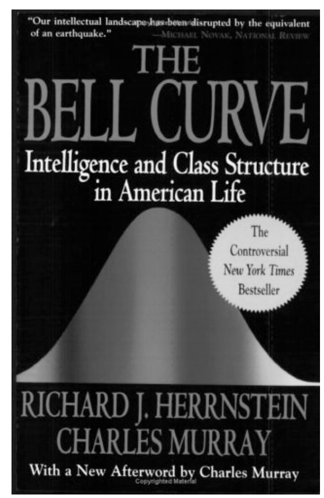
Disruptive selection on black-bellied seedcrackers: Birds with either large bills or small bills (shaded bars) have the best chance of survival; others (clear bars) die. (Source: Bates Smith, 1993)



Competition among finch species in the Galápagos Islands creates *character displacement*. Bird species are more different from each other on islands where they compete with each other.

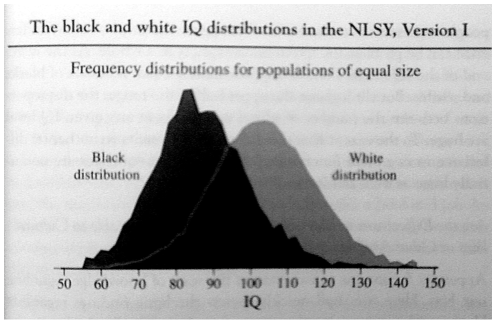


In 1994, a book by a Harvard psychologist and a political scientist at the American Enterprise Institute stirred up more than a little controversy. . .

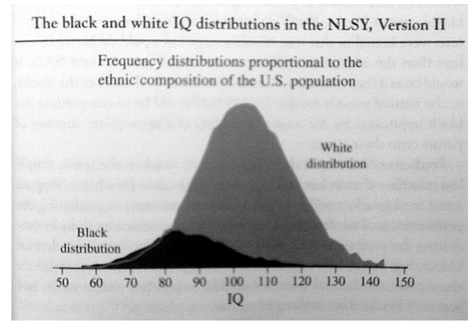


". . . ethnic differences in cognitive ability are neither surprising nor in doubt. Large human populations differ in many ways, both cultural and biological. It is not surprising that they might differ at least slightly in their cognitive characteristics. One message of this chapter is that such differences are real and have consequences."
—ch. 13

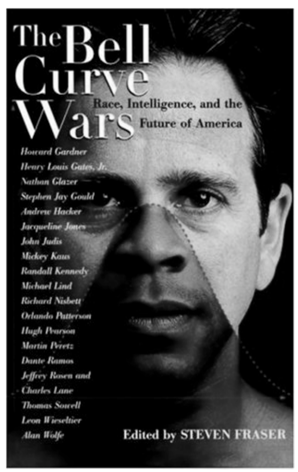
Herrnstein and Murray argued that the IQ distribution of African-Americans was about one standard deviation less than that of European-Americans, with African-Americans averaging an IQ of 85 and Europeans averaging about 100.



The picture looks worse if you take population size into account!



As might be expected, this modest little proposal stirred up just a bit of controversy in some circles. Let's get a bit deeper into the argument and see if we can't evaluate it. . .



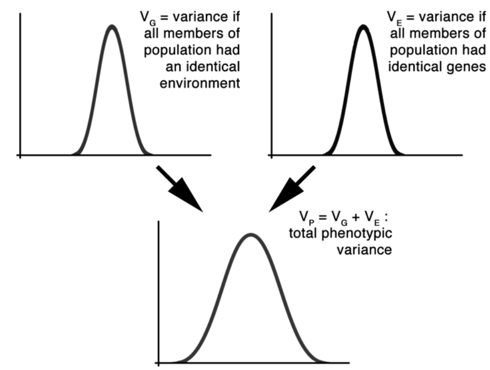
Variance

- The *variance* in a quantitative trait is the mean of the squared differences between each data point and the average
  - The square root of the variance is better known as the *standard deviation*
  - You can intuitively think of variance as a measure of the width of a bell-curve distribution
- We can represent the total variance by V_P (total phenotypic variance)

Variance

- Some of the variance comes from genetic variation in the population: call that V_G
- Some of the variance comes from environmental variation in the population: call that V_E
- V_P (total phenotypic variance) = V_G (genetic variance)+ V_E (environmental variance)

If you could separate out V_G and V_E, the curves would look like this. . .



Variance—*BIG DISCLAIMER*

- These equations apply only to variance within a population—*not* to one individual's trait!
  - To say something like "70% of my height is due to genes and 30% to eating my Wheaties" is meaningless.
- They also don't apply to variance *between* different populations.

Heritability

- We can define the *broad-sense heritability* of a trait to be $H^2 = V_G/V_P$
  - A trait could be inherited genetically and have zero heritability, if it has no genetic variance (e.g. hair color, in a population of black-haired individuals who all dye their hair different colors).
  - A trait could even be fully genetically controlled and have *undefinable* heritability, if it has no variance at all (e.g. number of noses per person—since everyone has exactly one, $V_P = 0$ and H^2 is undefined).

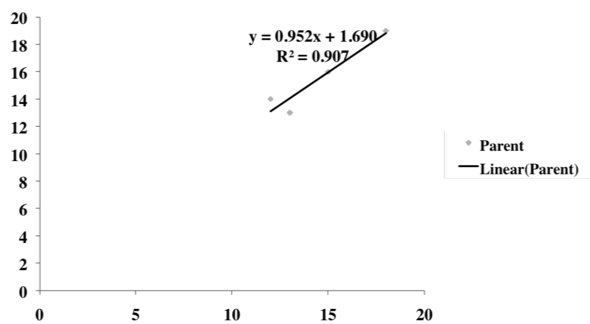
Heritability II

- We can define the *narrow-sense heritability* of a trait to be $h^2 = V_A/V_P$
  - V_A, the *additive genetic variance*, is the amount of genetic variance that depends only on the number of alleles (and not on things like genetic dominance, epistasis, and so on)

R=h²S

- What h^2 is good for is predicting whether or not selection will be effective in changing the mean value of a trait in a population.
- R = *response to selection* (= difference between mean trait in parents and mean trait in offspring)
- S = *selection differential* (=difference between mean trait in general population and mean trait in population selected for breeding)

h^2 can be estimated as the slope of the linear correlation between parental and offspring phenotypes. Old class data for parental vs. offspring height gives a value of 0.952 for h^2. (Larger sample sizes give a value of about 0.7 for h^2.)



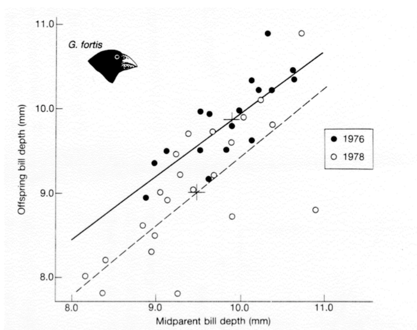


Figure 9.1 Parents with larger than average beaks produce offspring with larger than average beaks in *Geospiza fortis* on Daphne Major: beak size is inherited. From Grant (1986).

Graphing mean parent vs. mean offspring beak size in Galápagos finches gives straight lines with a slope of about 0.8, which is the narrow-sense heritability. The slope doesn't change from before a drought (1976) to after the drought (1978), suggesting that we are in fact measuring something genetic.