Heritability

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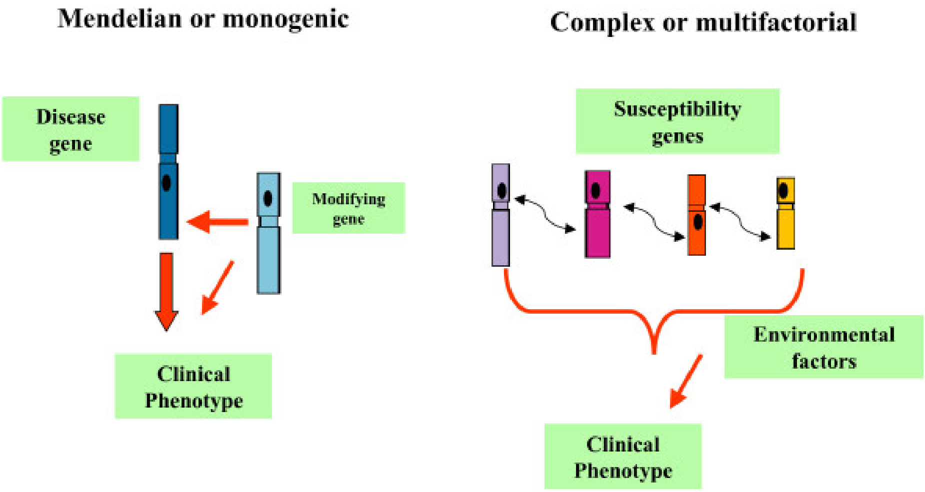
Genetic disease



Heredity

- Traits are passed from parents to children
- Some traits tend to dominate other traits
- **Allele** - alternative forms of a gene
- Simplifying assumption: some traits are all-or-nothing. E.g. eye color - one allele (b) is for blue eyes, another allele (B) is for brown eyes
  - **Bb** - heterozygous
  - **bb** - homozygous
- **Genotype** - what alleles you have
- **Phenotype** - what traits you have
- **HERITABILITY** - the proportion of the variation in a given characteristic or state that can be attributed to (additive) genetic factors.

Punnett square

	B	b
B	BB	Bb
b	Bb	bb

- Many different genotypes correspond to the same phenotype
- Two hybrids produce blue-eyed offsprings with 25% probability
- Two hybrids produce heterozygous offsprings with 50% probability

Fun with Punnett square

- Mom: BB
- Dad: Bb

	B	B
B	BB	BB
b	Bb	bB

- Blue eyes - **bb** - 0%
- Heterozygous dominant - **Bb** - 50%

Incomplete dominance

- Red flower
- White flower

	R	W
R	RR	RW
W	RW	WW

Mixing (blending) of traits. E.g., RW - pink

Blood types

A B O

O - recessive, A and B are codominant

	A	B
A	AA	AB
O	AO	BO

AB - AB blood type

P(A blood type) $=$ AA and AO $=$ 50%

Independent assortment

If alleles are on different chromosomes, one allele is said to be independent on another

- b - blue eyes
- B - brown eyes (dominant)
- t - small nose
- T - big nose (dominant)

BbTT - brown eyes, big nose

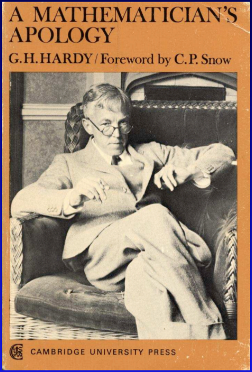
Independent assortment

Parents: both are dihybrids BbTt

	BT	Bt	bT	bt
BT	BTBT	BTBt	BTbT	BTbt
Bt	BtBT	BtBt	BtbT	Btbt
bT	bTBT	bTBt	bTbT	bTbt
bt	btBT	btBt	btbT	btbt

- Brown eyes, big nose - 9
- Brown eyes, small nose - 3
- Blue eyes, big nose - 3
- Blue eyes, small nose - 1 (1/16)

Hardy-Weinberg principle (1908)



Godfrey Harold Hardy (1877-1947)

Wilhelm Weinberg (1862-1937)

Hardy-Weinberg principle (1908)

Given a population with a locus with two alleles and discrete generations and these assumptions:

- The population is infinitely large
- There is no mutation
- There is no immigration or emigration
- There are no differences among the genotypes in viability
- There are no differences among the genotypes in fertility
- There are no differences in frequencies of genotypes between females and males

then if we start with genotype frequencies, we can calculate the frequencies of the genotypes in the next generation

Modeling allele sampling with the binomial distribution

- The binomial distribution with parameters n and p is the discrete probability distribution of the number of successes in a sequence of n *independent yes* (e.g., "heads" or "reference allele") or *no* (e.g., "tails" or "alternate allele") experiments, each of which yields success with probability p
- The probability of getting exactly k successes in n trials is given by the probability mass function:

$$Pr(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

- What is the probability of seeing $k = 1$ tails in $n = 3$ flips of a fair coin with the probability of a tail $(p) = 0.5$?
- 3 *choose* $1 = 3$; $0.5^1 = 0.5$; $(1 - 0.5)^{(3-1)} = 0.25$. So, $3 * 0.5 * 0.25 = 0.375$
- In R: `dbinom(1, size=3, prob=0.5)`

Hardy-Weinberg equilibrium

- The binomial distribution of genotypes in a population, such that frequencies of genotypes **AA**, **Aa** and **aa** will be p^2, $2pq$, and q^2, respectively, where p is the frequency of allele **A**, and q is the frequency of allele **a**.
- Hardy–Weinberg equilibrium applies in a population when there are no factors such as migration or admixture that cause deviations from p^2, $2pq$ and q^2.

Hardy-Weinberg principle

- Blue - **b**, p - allele frequency of **b**
- Brown - **B** (dominant), q - allele frequency of **B**

For two individuals **Bb** and **bb**, genotype frequency of **b** is 75%, frequency of **B** is 25%. Phenotype frequency for blue eyes - 50%, for brown eyes - 50%

$$p + q = 100\% = 1, \; q = 1 - p$$

$$p^2 + 2pq + q^2 = 1$$

- p^2 - probability of **bb** from both parents
- q^2 - probability of **BB** from both parents
- $2pq$ - two ways of have hybrid alleles **Bb** or **bB**. Frequency of hybrids in a population

Hardy-Weinberg principle

- Say, population is 1M
- 9% have blue eyes. Must have $bb = p^2 = 0.9$, $p = \sqrt{0.9} = 0.3$
- 91% have brown eyes. What percent will be **BB**?

https://www.youtube.com/watch?v=4Kbruik_LOo&index=16&list=PL7A9646BC5110CF64

http://www.tiem.utk.edu/~gross/bioed/bealsmodules/hardy-weinberg.html