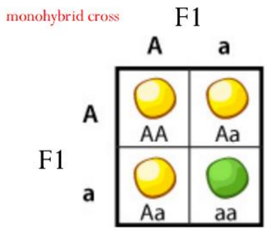
Lecture 2: Gene Inheritance and Transmission

Mendel's breeding experiments

In 1856, Mendel performed hybridisation experiments on pea plants- easy to grow and cross-breed experimentally. Also reproduce well and grows to maturity in a season. Mendel created 'pure breeding' strains for various traits- meant they were homozygous for a particular trait.

He noted that in 1st generation (F1) cross of these strains, certain (recessive) traits disappeared. However, in the F2 crosses they reappeared, because heterozygous parents have been crossed together, end up with 3:1 phenotype ratio. A punnet square shows how the traits are inherited (A=



dominant trait, a = recessive trait).

Dihybrid Cross

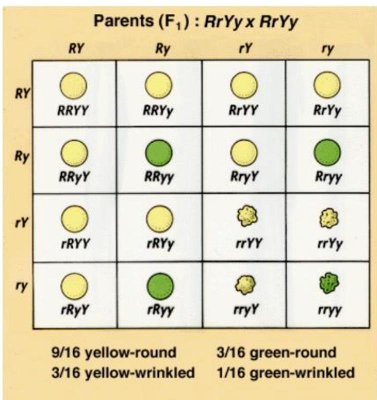
While Mendel's experiments with mixing one trait always resulted in a 3:1 ratio between dominant and recessive phenotypes, his experiments with mixing two traits (dihybrid cross) showed 9:3:3:1 ratios.

The punnet square method is useful for beginners but has limitations beyond a two gene situation. A trihybrid cross would be a complicated Punnet square- can get ridiculous:

	ABC	ABc	AbC	Abc	aBC	aBc	abC	abc
ABC	AABBCC	AABBCc	AABbCC	AABbCc	AaBBCC	AaBBCc	AaBbCC	AaBbCc
ABC	AABBCC	AABBCc	AABbCC	AABbCc	AaBBCC	AaBBCc	AaBbCC	AaBbCc
ABC	AABBCC	AABBCc	AABbCC	AABbCc	AaBBCC	AaBBCc	AaBbCC	AaBbCc
ABC	AABBCC	AABBCc	AABbCC	AABbCc	AaBBCC	AaBBCc	AaBbCC	AaBbCc
aBC	AaBBCC	AaBBCc	AaBbCC	AaBbCc	aaBBCC	aaBBCc	aaBbCC	aaBbCc
aBC	AaBBCC	AaBBCc	AaBbCC	AaBbCc	aaBBCC	aaBBCc	aaBbCC	aaBbCc
aBC	AaBBCC	AaBBCc	AaBbCC	AaBbCc	aaBBCC	aaBBCc	aaBbCC	aaBbCc
aBC	AaBBCC	AaBBCc	AaBbCC	AaBbCc	aaBBCC	aaBBCc	aaBbCC	aaBbCc

The Forked-Line Method

Relies on the simple application of the laws of probability established for the dihybrid cross. Each gene pair is assumed to behave independently during gamete formation. Doesn't work if the genes are linked.



Example: Male with genotype AaBBCc mates with female having genotype aaBbCc. What are the expected genotype frequencies of their offspring?

P = AaBBCc x aaBbCc

- The first step is to decompose the trihybrid cross into its constituent single-gene (monohybrid) crosses

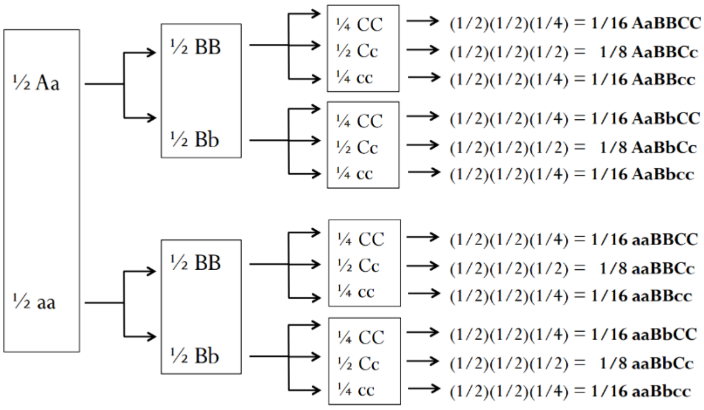
Aa x aa BB x Bb Cc x Cc

- Determine the expected genotype frequencies for these monohybrid crosses
  - You can use the Punnett square

Aa x aa	BB x Bb	Cc x Cc
½ Aa	½ BB	¼ CC
½ aa	½ Bb	½ Cc
		¼ cc

- Then create all possible genotype combinations
  - Pair every genotype from the first monohybrid cross with every genotype from the second cross with every genotype from the third

Now we traverse each path through the forked lines, one path at a time, in order to determine each trihybrid genotype and frequency.



The probability method

The most flexible and applicable method. A dihybrid cross is a situation in which two monohybrid crosses are involved and problems can sometimes be more easily solved by considering the two crosses independently (if the loci are unlinked) and then combining the results. The same principle applies, no matter how many gene loci are involved.

There are two rules of probability you need to understand – Multiplication and Addition.

Multiplicative Rule

If two events are independent of each other, then the probability of them occurring at the same time is the product of their independent probabilities.

$$p(A \text{ and } B) = p(A) \times p(B)$$

Eg, what is the probability of flipping a coin 5 times and getting tails on every flip? (Independent events- one event does not influence the other).

A: ½ x ½ x ½ x ½ x ½ = 1/32

In a cross between pea plants that are heterozygous for purple flower colour (Pp), what is the probability that offspring will be homozygous recessive?

A: ½ x ½ = ¼

Additive Rule

If two events are mutually exclusive, then the probability that at least one of them occurs is the sum of their individual probabilities.

$$P(C \text{ or } D) = p(C) + p(D)$$

Eg. What is the probability of flipping a coin and getting either a head or tail?

A: ½ + ½ = 1 (100% of the time)

- In a cross between AaBbCc x AaBBCC what is the probability that the offspring will be AABbCc or AABBCC?

	What is the probability Aa x Aa will give AA?		What is the probability Bb x BB will give Bb?		What is the probability Cc x CC will give Cc?	
AABbCc	1/4	x	1/2	x	1/2	= 1/16
	What is the probability Aa x Aa will give AA?		What is the probability Bb x BB will give BB?		What is the probability Cc x CC will give Cc?	
AABBCC	1/4	x	1/2	x	1/2	= 1/16

$$1/16 + 1/16 = 2/16 = 1/8$$

The Binomial Theorum

The binomial theorem expansion provides a useful tool to readily obtain expressions for probabilities in genetic situations where the sum of the probabilities for alternative events equals one.

$$(p + q)= 1$$

$$(p + q)^2 = p^2 + 2pq + q^2 \quad \text{etc.}$$