FRST302: Forest Genetics

Lecture 1.1: Classical Genetics and its Molecular Mechanisms

Outline for Today

- Short history of genetics
- Mendel's laws
- Chromosomes

What is genetics?

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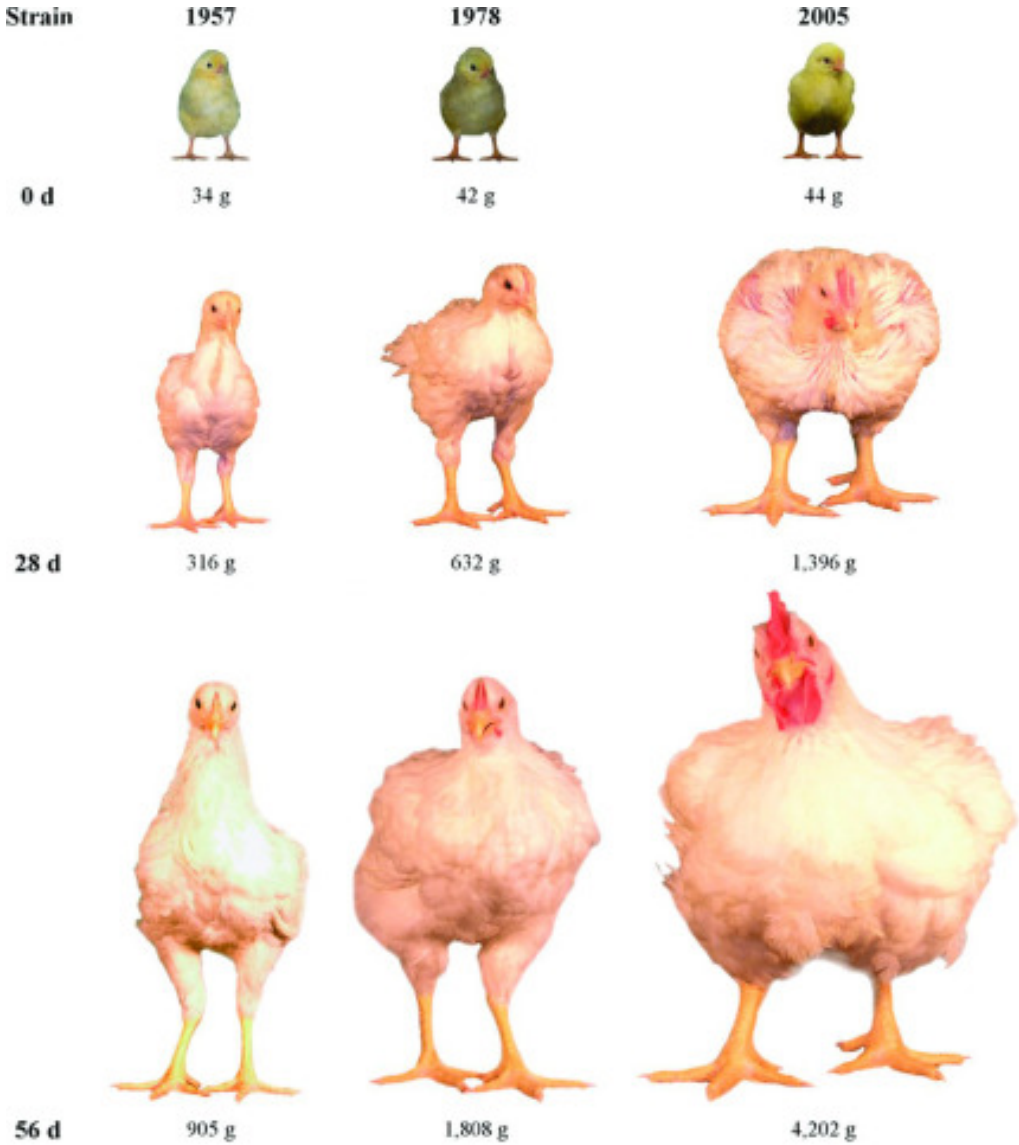
Genetics is the study of genes, of variation and heredity across all branches of the tree of life

What are the major questions in genetics?

How can we apply a knowledge of genetics?



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[1] Modified from Figure 1 - Zuidhof et al. 2014

History of Genetics

Humans have probably pondered inheritence for all history:

- For much of history, the mechanisms of inheritence were basically unknown
- The inheritance of acquired characteristics was widely accepted for much of history (from Hippocrates to Aristotal to Lamarck)

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- *Early microscopists thought that they had seen small humans inhabiting sperm cells!*

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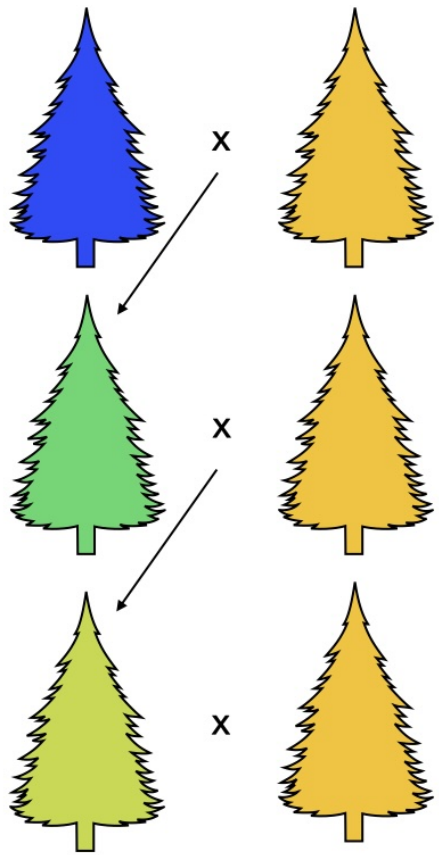
History of Genetics

By the 19th Century, the dominant theory was **blending inheritance**

- The notion that an offspring's traits are simply the average of the parents' traits.
- This is intuitively appealing - continuously varying traits are often intermediate between their parents
- *There is one big problem with blending inheritance!*



What's the big problem with blending inheritance?

Darwin's Thoughts on Inheritance

"'The laws governing inheritence are quite unknown; no one can say why the peculiarity in different individuals of the same species... is sometimes inherited and sometimes not so" [a]

But, Darwin clearly appreciated the limitations of blending and felt the need for an alternative:

"Each parent transmits it peculiarities, therefore if varieties allowed to cross... such varieties will be constantly demolished" [b]

A NICE PIC OF DARWIN?

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[a] *Ch. 1, The Origin of Species, C. Darwin 1859*

[b] *Foundations of the 'Origin of Species', F. Darwin 1909*

Trait Variation

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- Discrete - traits that exhibit categorical differences (e.g. different leaf forms, distinct flower colour)
- Ordinal - discrete traits with some informative order (e.g. high, medium and low shade tolerance)

Particulate Inheritance

Through careful experimentation analysing discrete traits in peas, Franciscan Friar Gregor Mendel found evidence supporting a model of particulate inheritence

Mmmmm...
Peas Peas Peas Peas Peas

Particulate Inheritance

Particulate Inheritance: traits are passed from parent to offspring via particles

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Blending Inheritance

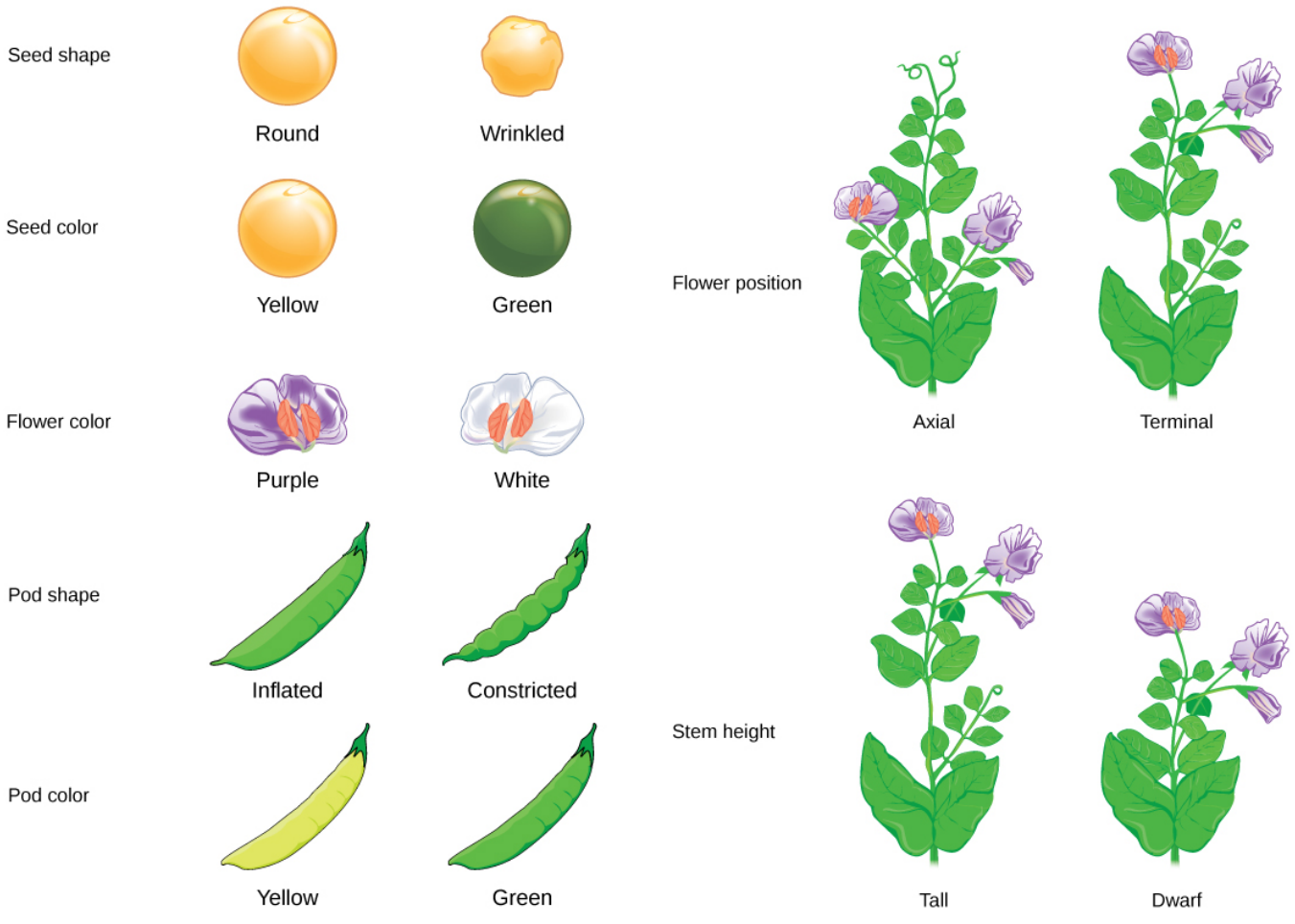
- Offspring exhibit averages of parental traits
- The "blended" traits are transmitted to offspring
- Variation is rapidly lost across generations

Particulate Inheritance

- Offspring exhibit *combinations* of parental traits
- Parental traits can manifest in offspring (or skip generations)
- Variation is maintained over time

Mendel's Crosses

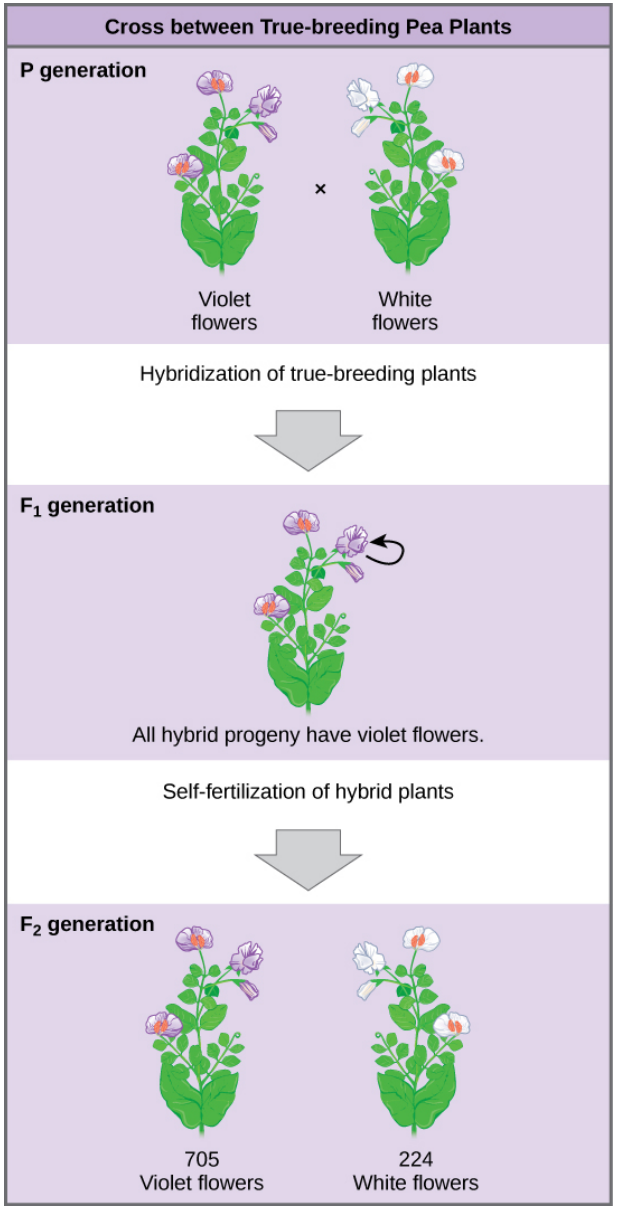
Mendel examined variation and inheritence of several discrete characteristics of pea plants



Mendel's Crosses

Garden peas are capable of self-fertilization, so Mendel was abel to generate "true" lines of peas that exhibit a particular trait/phenotype

- Crossing lines produces an F1 generation
- The patterns of variation among the F2 generations were Mendel's focus



Mendel's Crosses

Note the 3:1 ratios of the two pea phenotypes in the F2

Mendel's Laws

The patterns of variation that Mendel observed led him to develop three laws of inheritance

- Law of Segregation
- Law of Dominance
- Law of Independent Assortment

Mendel's Laws

The law of segregation: each individual possesses a pair of particles for any particular trait and each parent passes one of these randomly to its offspring

The law of dominance: for some traits, the presence of one kind of particle masks the presence of another. Mendel referred to the **dominant** particle as masking the effects of the **recessive** particle

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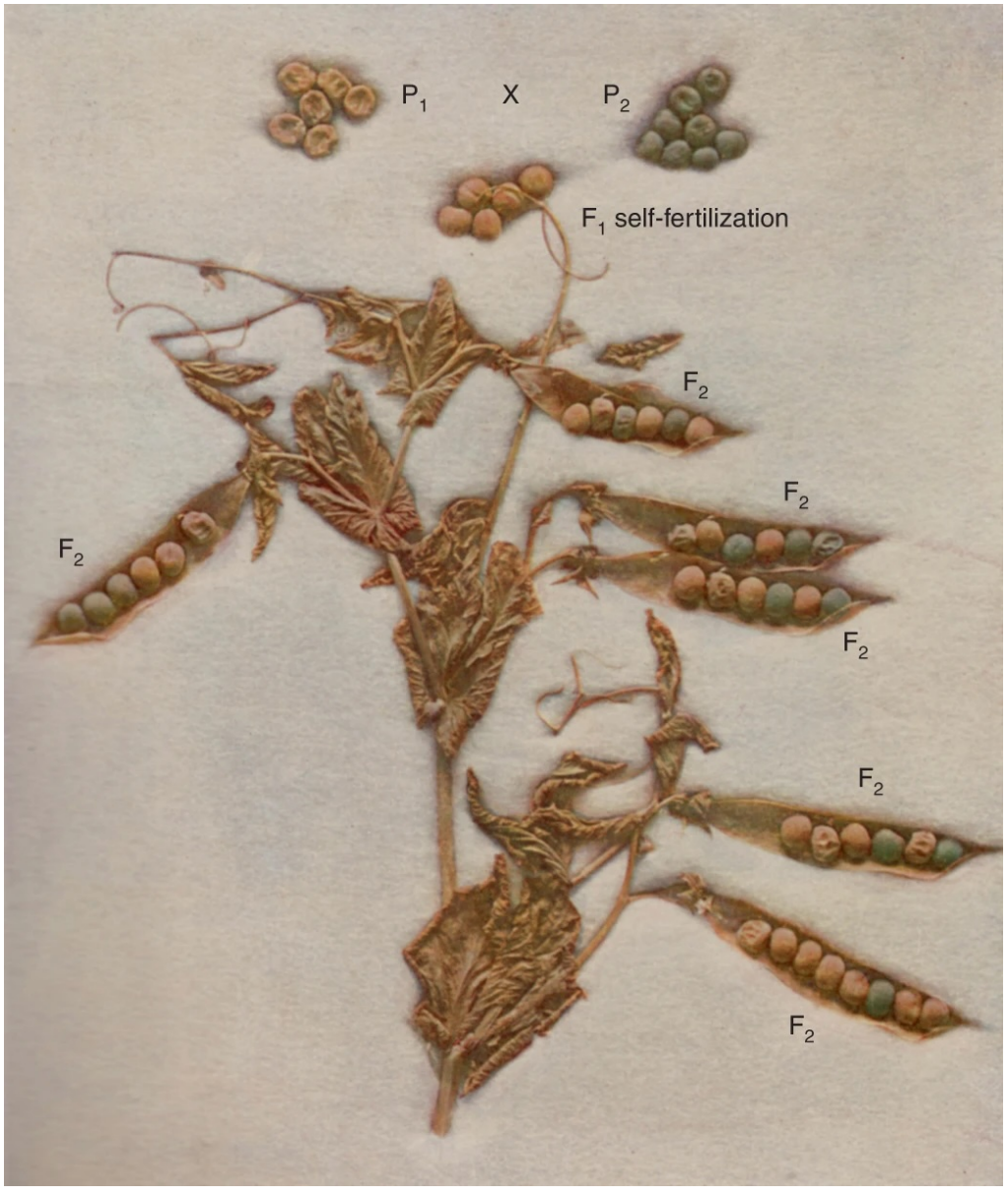
The law of independant assortment: when two individuals differ in more than two pairs of traits (e.g. smooth v. wrinkly and green v. yellow), the inheritance of one pair of traits is independent of another

Mendel's Laws



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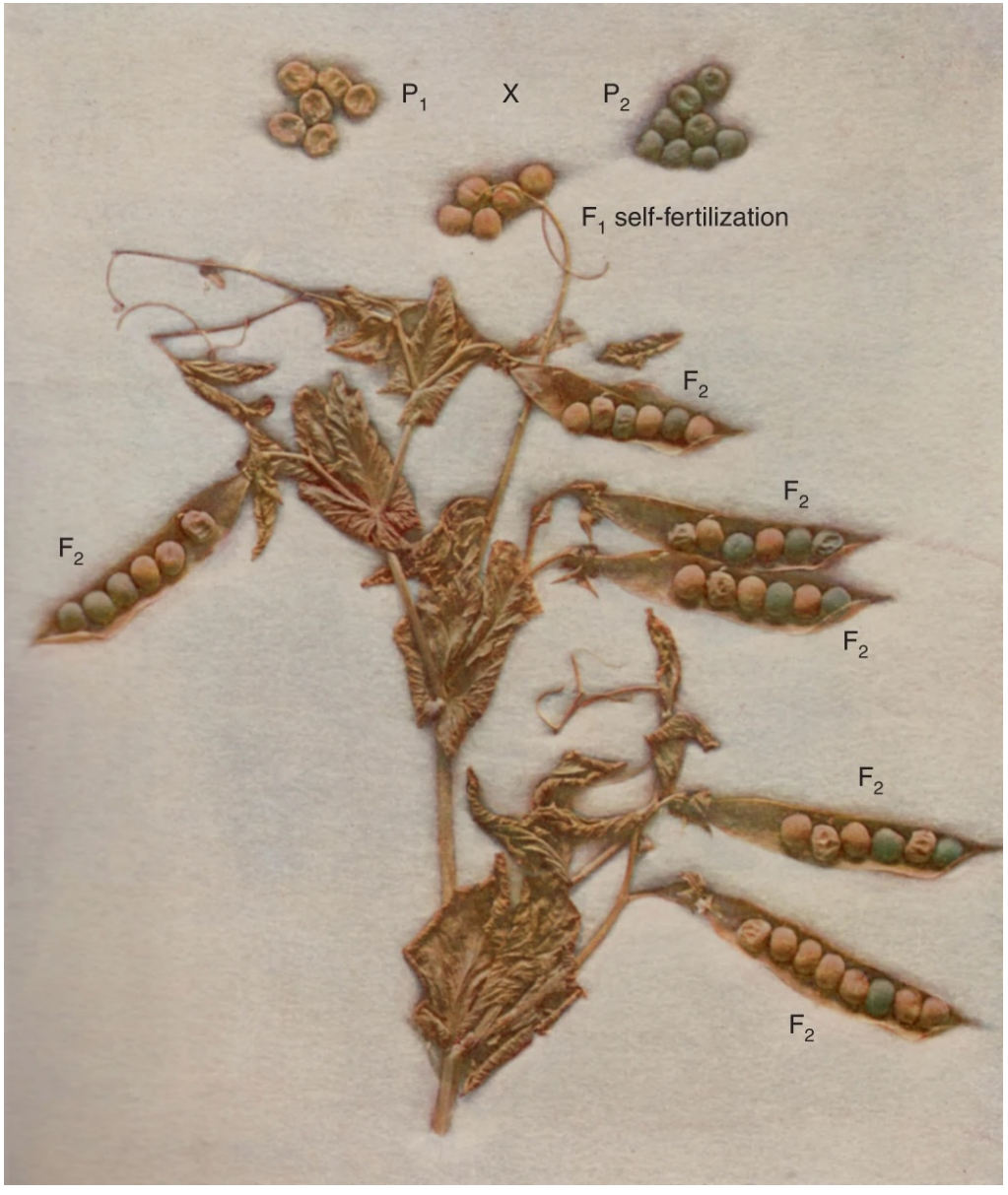
How does the image demonstrate **the law of segregation**?

Mendel's Laws

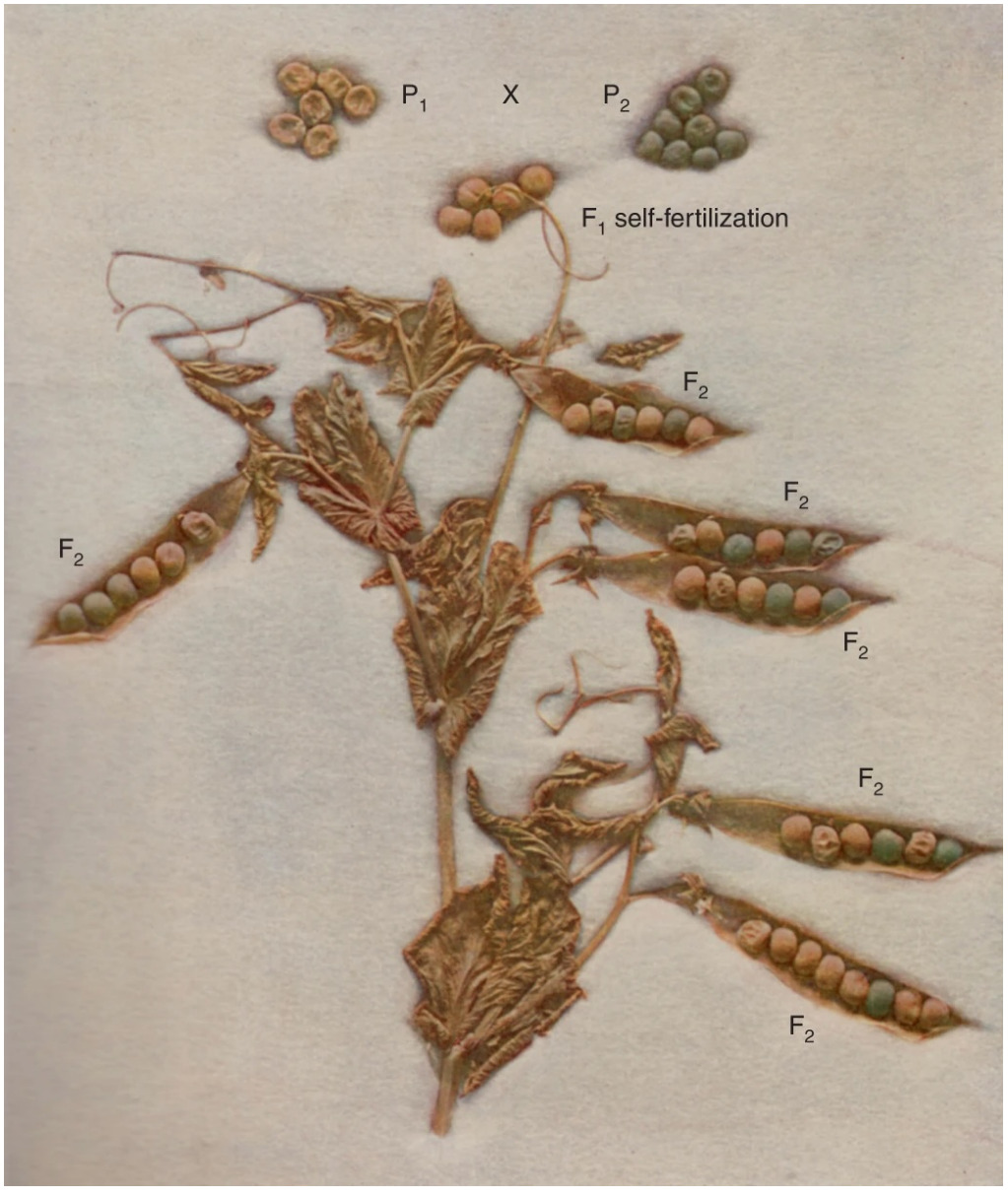


The law of segregation: each individual possesses a pair of particles for any particular trait and each parent passes one of these randomly to its offspring

How does the image demonstrate **the law of segregation**?

Answer: *Individuals (i.e. seeds) in the F2 generation exhibit a combination of seed colours and textures*

Mendel's Laws



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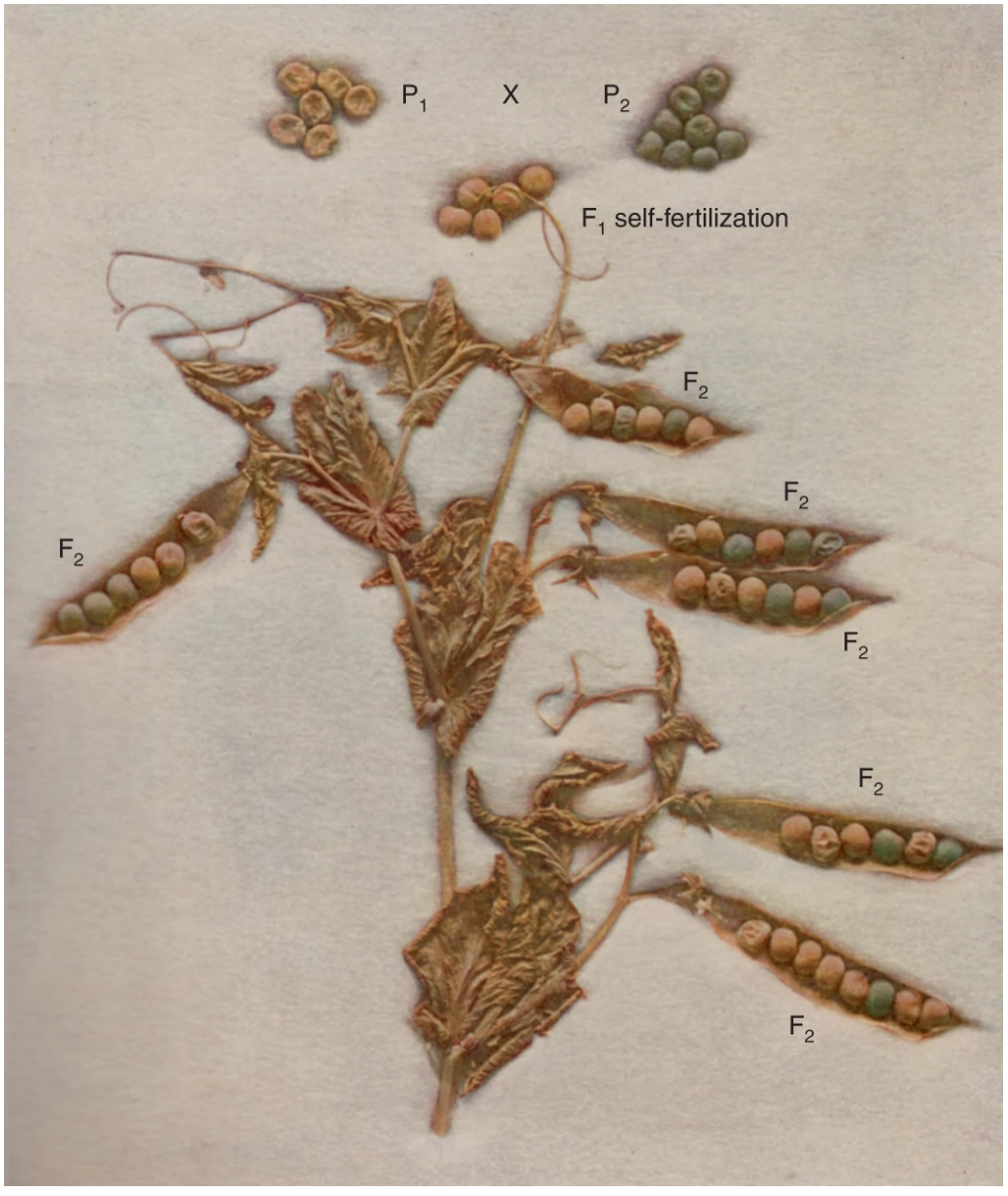
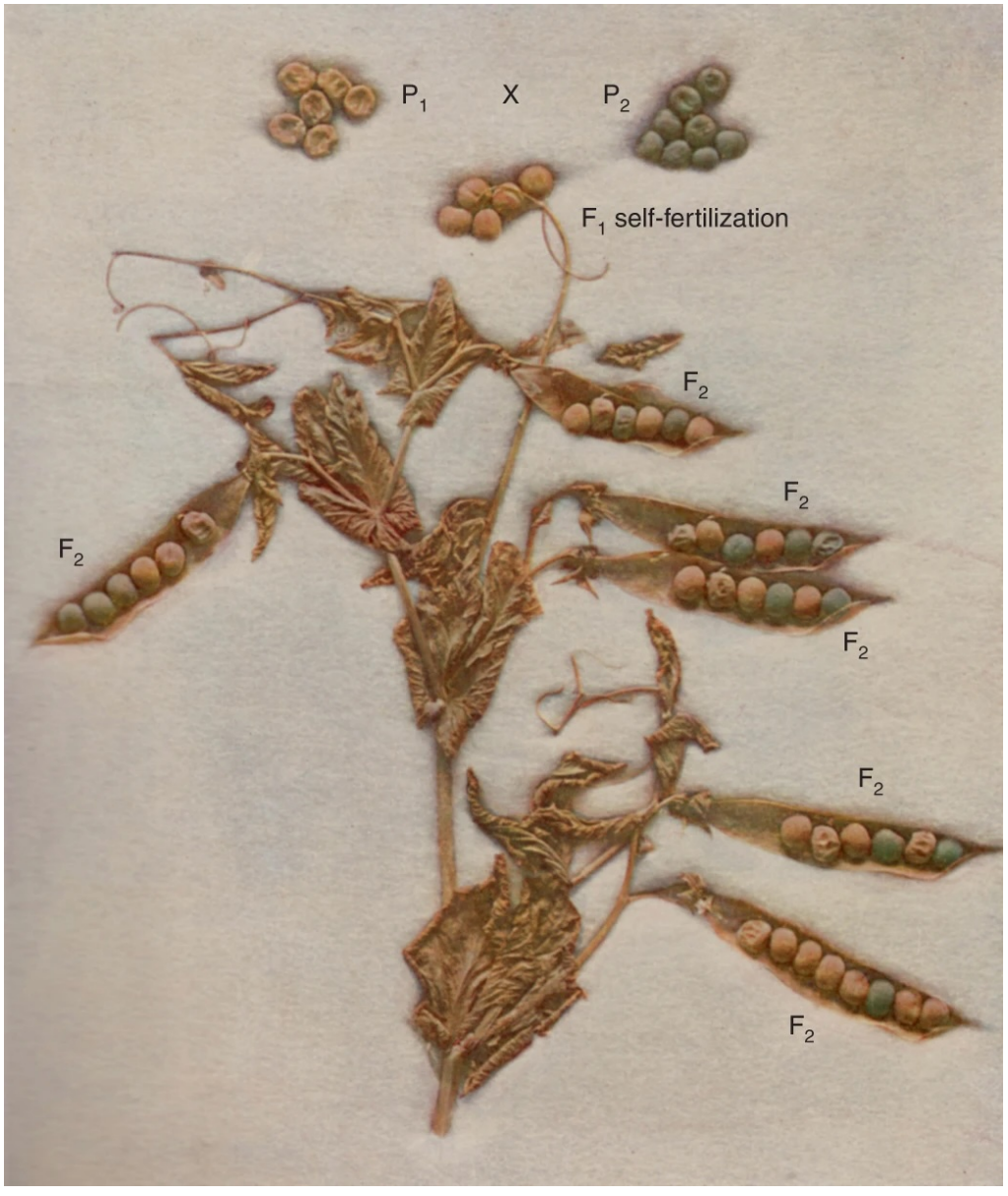


The law of dominance: for some traits, the presence of one kind of particle masks the presence of another.

How does the image demonstrate **the law of dominance**?

Answer: *The uniformity of trait values in the F1 generation*

Mendel's Laws



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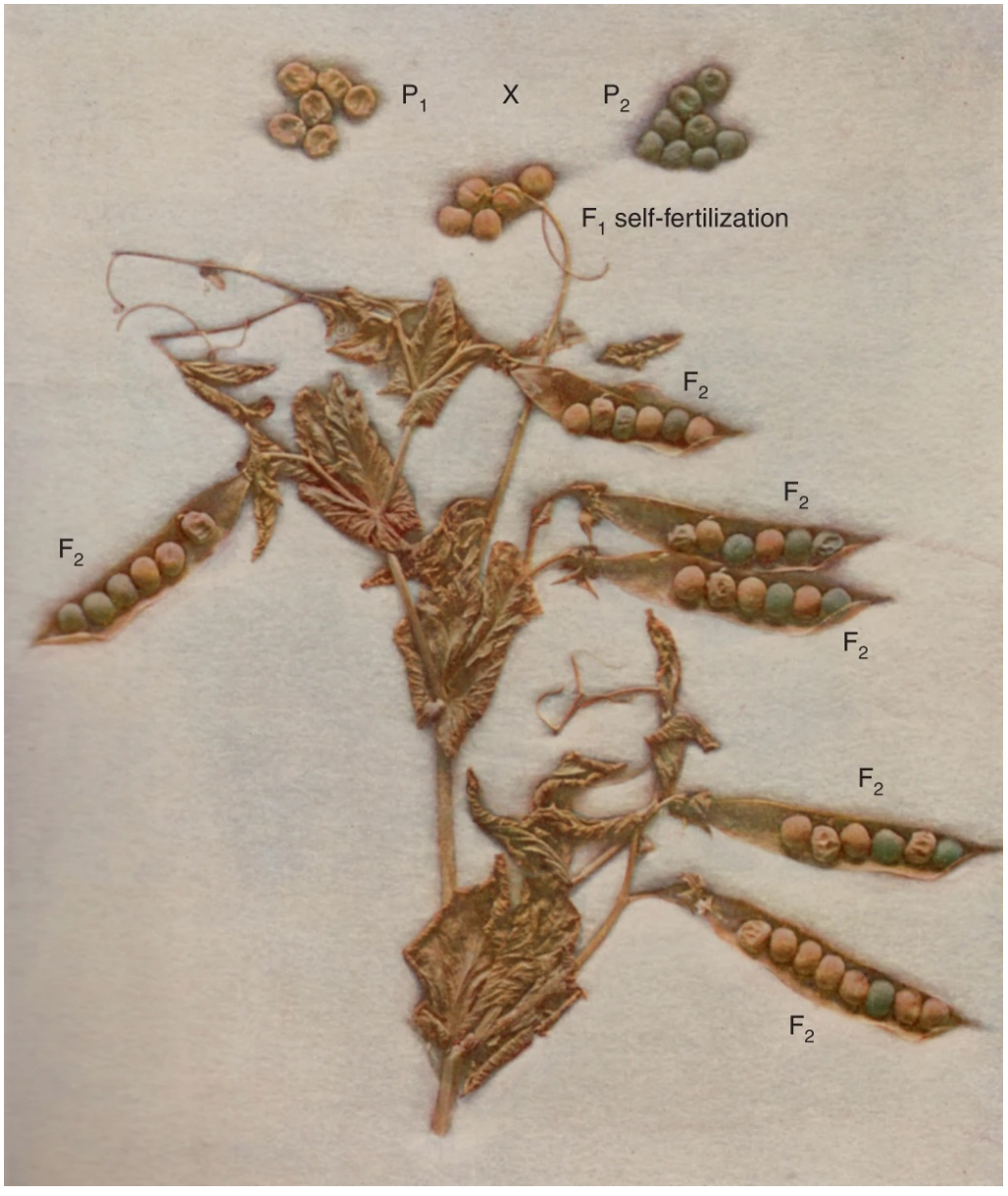

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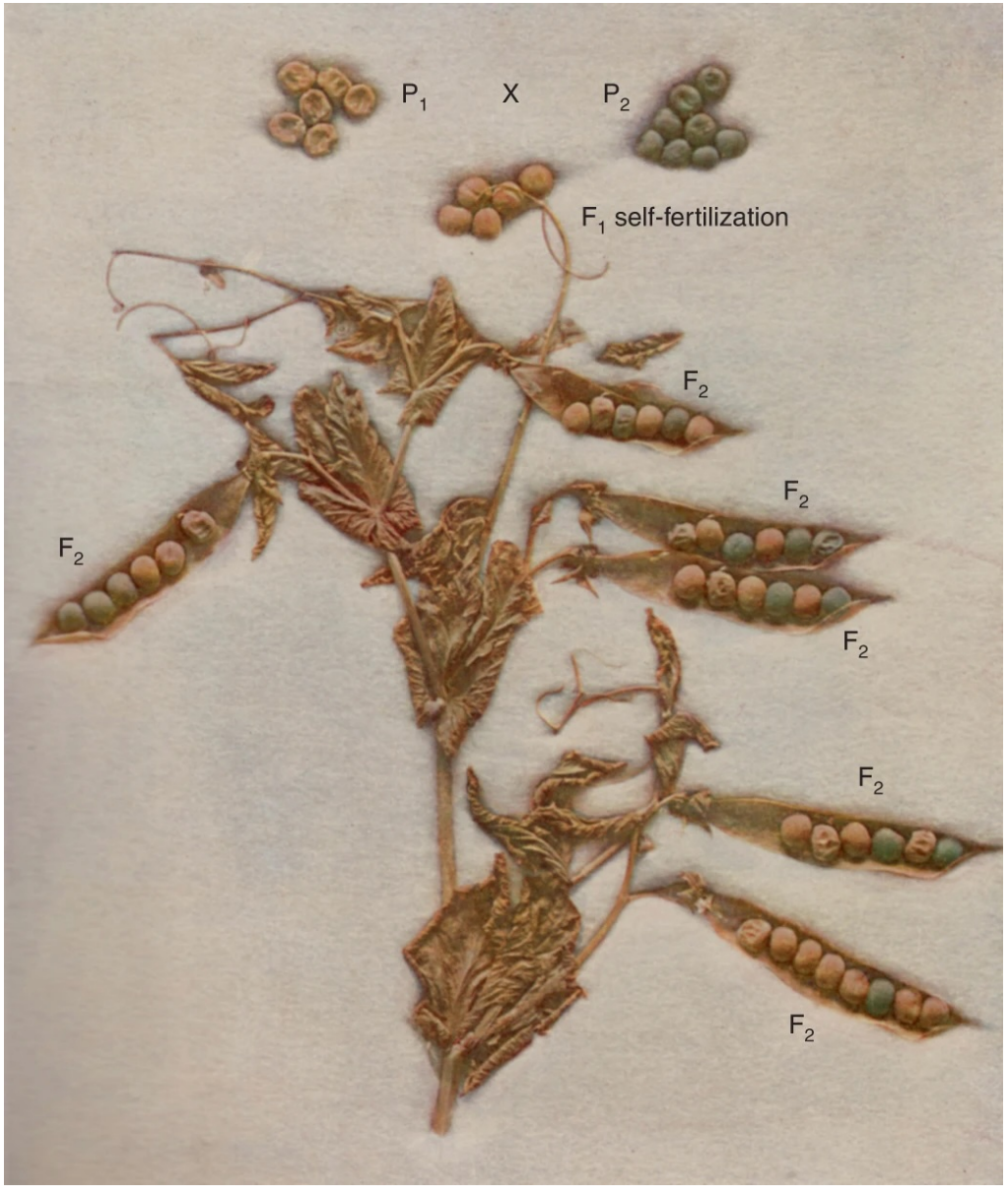
How does the image demonstrate **the law of independant assortment**?

Answer: *The fact that wrinkly green peas and smooth yellow peas are seen in the F2 generation*

Mendel's Laws



I count 38 F2 seeds

13 Green : 25 Yellow
9 Wrinkly : 29 Smooth

Why do we see these ratios?

Mendelian Terminology

Remember, Mendel crossed "true" green (**G**) peas with "true" yellow (**Y**) peas.

The table below gives the results of the self-fertlization of the F1 generation

		GY	
		G	**Y**
YG	**G**	GG	YG
	Y	YG	YY

Codominance

×

A leaf shape trait controlled by a single gene

Assuming the two individuals are homozygotes, how could you figure out if the allele for the cut leaf phenotype is dominant, recessive or codominant?

Test Crosses

Leaf phenotypes in European beech, *Fagus sylvatica*

×

A leaf shape trait controlled by a single gene

Assuming the two individuals are homozygotes, how could you figure out if the allele for the cut leaf phenotype is dominant, recessive or codominant?

Particulate Inheritance and Classical Genetics

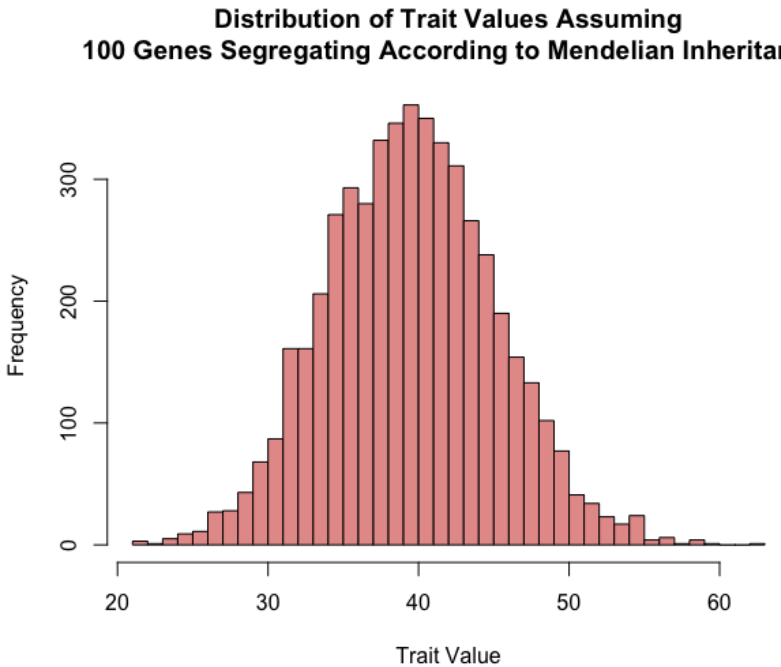
- Proposed in 1865 and 1866
- 6-7 years after Darwin's Theory of Evolution
- As far as anyone knows, Darwin was totally unaware of Mendel*but see notes!*

- Represents the foundation of classical genetics
- **Classical genetics** refers to the study of genetic patterns observable from reproductive events

More peas please

Reconciling the Mendelians and the Biometricians

Mendel's results went largely unnoticed in his lifetime, but they were rediscovered and publicised in the early 1900s



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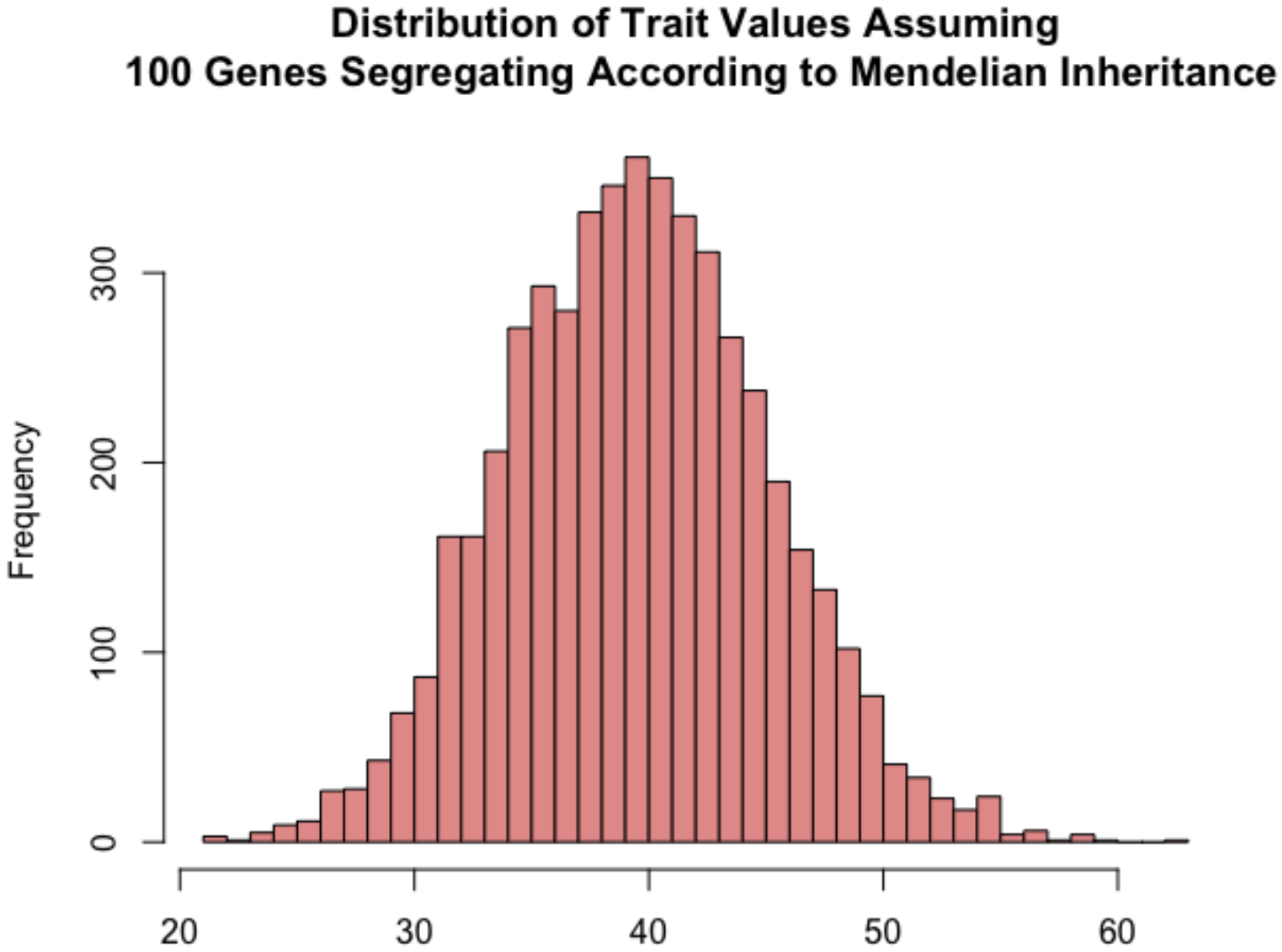

Branches of Genetics

- Behavioural genetics
- **Classical genetics**
- Developmental genetics
- **Conservation genetics**
- **Ecological genetics**
- **Evolutionary genetics**
- **Genecology**
- Genetic engineering
- Genomics
- Medical genetics
- Forensics
- Molecular genetics
- **Quantitative genetics**
- **Population genetics**
- Phylogenetics
- Statistical genetics
- Genetic epidemiology
- Archaeogenetics

A non-complete and *slightly* biased list

Extra Material

Below is the R code to make the figures on the infinitesimal model - feel free to play around with it

```
# Demonstrate the distribution of trait values for a quantitative trait
# Under Mendelian segregation for an arbitrary number of genes
# Assumes random mating, constant effect sizes, constant allele frequencies

nGenes = 100
alleleFrequency = 0.2
popSize = 5000
effectSize = 1

hist(
        replicate(popSize,
                sum(  1 * rbinom(nGenes, 2, alleleFrequency) ) ),
        col = "#e69b99",
        xlab=  "Trait Value",
        main= paste("Distribution of Trait Values in F2s Assuming\n",nGenes,
                "Genes Segregating According to Mendelian Inheritance"),
        breaks = 40)
```