


## Mendelian Genetics

Augustinian Monk at Brno Monastery in Austria (now Czech Republic)

Not a great teacher but well trained in math, statistics, probability, physics, and interested in plants and heredity.




**Gregor Mendel**  
"Father of Genetics"

While assigned to teach, he was also assigned to tend the gardens and grow vegetables for the monks to eat.

Mountains with short, cool growing season meant pea (*Pisum sativum*) was an ideal crop plant.

## Contributions in 1860s (US Civil War Era)

- Discovered Genes as Particles of Inheritance
- Discovered Patterns of Inheritance
- Discovered Genes Come from **Both** Parents
  - Egg + Sperm = Zygote
  - Nature vs Nurture
  - Sperm means Seed (Homunculus)
- Discovered One Form of Gene (Allele) Dominant to Another
- Discovered Recessive Allele Expressed in Absence of Dominant Allele



### Mendel worked with peas (*Pisum sativum*)

- Good choice for environment of monastery
- Network provided unusual varieties for testing
- Obligate self-pollination reproductive system
  - Permits side-by-side genetic barriers
  - Cross-pollinations require intentional process
- Crosses meticulously documented
- Crosses numerically/statistically analyzed
- Scientists of 1860s could not understand math
- Work lost in journals for 50 years!
- Rediscovered in 1900s independently by 3 scientists
- Recognized as landmark work!

### One Example of Mendel's Work

<b>P</b>	Tall DD <b>Homozygous Dominant</b>	x	Dwarf dd <b>Homozygous Recessive</b>	Phenotype Genotype
<b>F1</b>	All Tall Dd <b>Heterozygous</b>		Clearly Tall is Inherited... What happened to Dwarf? 1. Tall is dominant to Dwarf 2. Use D/d rather than T/t for symbolic logic	
<b>F2</b>	Punnett Square: F1 x F1 = F2 possible gametes			
	D	d		
possible gametes	D Tall DD	d Tall Dd	3/4 Tall 1/4 Dwarf Dwarf is not missing...just masked as "recessive" in a diploid state... there IS a female contribution.	
d	D Tall Dd	d Dwarf dd		

### Mendel as a Scientist

**Test Cross:** Unknown Tall x Dwarf dd

If Unknown is DD: possible gametes D, d

D	Tall DD	Tall Dd
d	Tall Dd	Tall dd

Test Progeny All Tall

If Unknown is Dd: possible gametes D, d

D	Tall DD	Tall Dd
d	Dwarf dd	Dwarf dd

Test Progeny Half Tall Half Dwarf

1/3 of F2 Tall are DD  
2/3 of F2 Tall are Dd

### Another Example of Mendel's Work

<b>P</b>	Green gg <b>Homozygous Recessive</b>	x	Yellow GG <b>Homozygous Dominant</b>	Phenotype Genotype
<b>F1</b>	All Yellow Gg <b>Heterozygous</b>		Clearly Yellow is Inherited... What happened to Green? 1. Yellow is dominant to Green 2. Use G/g rather than Y/y for symbolic logic	
<b>F2</b>	Punnett Square: F1 x F1 = F2 possible gametes			
	G	g		
possible gametes	G Yellow GG	g Yellow Gg	3/4 Yellow 1/4 Green Green is not missing...just masked as "recessive" in diploid state	
g	G Yellow Gg	g Green gg		

NEVER use G/Y or g/y

### Mendel as a Scientist

**Test Cross:**  
Unknown Yellow x Green  
gg

**F2**  
Punnett Square: F1 x F1 = F2  
possible gametes: G, g

G	Yellow GG	Yellow Gg
g	Yellow Gg	Green gg

**If Unknown is GG:**  
possible gametes: G, g

G	Yellow Gg	Yellow Gg
G	Yellow Gg	Yellow Gg

Test Progeny: **All Yellow**

**If Unknown is Gg:**  
possible gametes: G, g

G	Yellow Gg	Yellow Gg
g	Green gg	Green gg

Test Progeny: **Half Yellow  
Half Green**

**1/3 of F2 Yellow are GG**  
**2/3 of F2 Yellow are Gg**

### Mendel as a Scientist

**Test Cross:**  
Unknown Yellow x Green  
gg

**Actual Results Decision**

3 Yellow 2 Green	Gg
2 Yellow 3 Green	Gg
1 Yellow 4 Green	Gg
0 Yellow 5 Green	Gg
4 Yellow 1 Green	Gg
5 Yellow 0 Green	GG

**Small families do not follow expected ratios perfectly!**  
**Rare, but it can happen!**  
**It only takes 1 green to be sure the unknown is Gg!**

**<5% chance unknown is Gg**  
 $1/2 \cdot 1/2 \cdot 1/2 \cdot 1/2 \cdot 1/2 = 1/32$   
**You could be wrong (rarely)!**

### Genetics After Mendel

**After 1900 several scientists tried to replicate Mendel's crosses using other species including snapdragon.**

**P** Red (p<sup>R</sup>p<sup>R</sup>) x Yellow (p<sup>Y</sup>p<sup>Y</sup>)

**F1** All Orange (p<sup>R</sup>p<sup>Y</sup>)

**F1 x F1 = F2**

**Punnett Square:**  
possible gametes: p<sup>R</sup>, p<sup>Y</sup>

p <sup>R</sup>	Red p <sup>R</sup> p <sup>R</sup>	Orange p <sup>R</sup> p <sup>Y</sup>
p <sup>Y</sup>	Orange p <sup>R</sup> p <sup>Y</sup>	Yellow p <sup>Y</sup> p <sup>Y</sup>

**This F2 will NOT have a 3:1 ratio of phenotypes.**  
**Instead it shows a 1:2:1 ratio!**  
**The exception here proves the rule.**

**When these alleles go walking, they both do some talking (codominance)!  
OK, so we cannot use R/r nor Y/y so we pick a third letter...P for the petal color gene.  
Notice: we do NOT mix R/Y or r/y!**

In addition to this, there are multiple alleles possible:  
p<sup>R</sup> = red p<sup>Y</sup> = yellow p = no pigment

The combination of alleles in a diploid determine the flower color:  
p<sup>R</sup>p<sup>R</sup> = red p<sup>R</sup>p = pink  
p<sup>R</sup>p<sup>Y</sup> = orange p<sup>Y</sup>p = cream  
p<sup>Y</sup>p<sup>Y</sup> = yellow pp = white

Human hair color follows a similar pattern:  
Alleles: H<sup>Bn</sup> = brown H<sup>Bd</sup> = blonde h<sup>R</sup> = red h<sup>Bk</sup> = black

The combinations of these alleles determine the base hair color:  
H<sup>Bn</sup>H<sup>Bn</sup> = dark brown H<sup>Bd</sup>H<sup>Bd</sup> = blonde h<sup>R</sup>h<sup>R</sup> = red  
H<sup>Bn</sup>H<sup>Bd</sup> = sandy brown H<sup>Bd</sup>h<sup>R</sup> = strawberry blonde h<sup>R</sup>h<sup>Bk</sup> = red  
H<sup>Bn</sup>h<sup>Bk</sup> = auburn blonde  
H<sup>Bn</sup>h<sup>Bk</sup> = dark brown H<sup>Bd</sup>h<sup>Bk</sup> = blonde

**h<sup>Bk</sup>h<sup>Bk</sup> = black**  
**Recessive can be common!**

**Dominant does NOT mean frequent!**

### Another Example of Recessive Being Common: *Pisum sativum*

Garden Peas: green seed, wrinkled seed, dwarf stature, white flower  
gg ww dd aa

**In other words: a quadruple double-recessive is the most common garden pea on Earth!**

**Quantitative Inheritance:** multiple genes control trait

Highest Crop Yield: AABBCCDDEE  
Intermediate Crop Yield: AabbCCDdEe  
Lowest Crop Yield: aabbccdde

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Darkest Skin Color: AABBCCDDEE  
Intermediate Skin Color: AaBbCcDdEe  
Lightest Skin Color: aabbccdde

**AaBbCcDdEe x AaBbCcDdEe can produce a huge range of colors!**  
**Yet TV talk show guests argue this point for Maury, etc.**

### Phenotype = Genotype + Environment

Crop Yield = Genotype  
+ Minerals  
+ Water  
+ Light  
- Pests  
etc.

**Optimizing these factors determines agricultural productivity...last part of our course!**

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Human Skin Color = Genotype  
+ Sun (UV) Exposure  
- Aging Factors

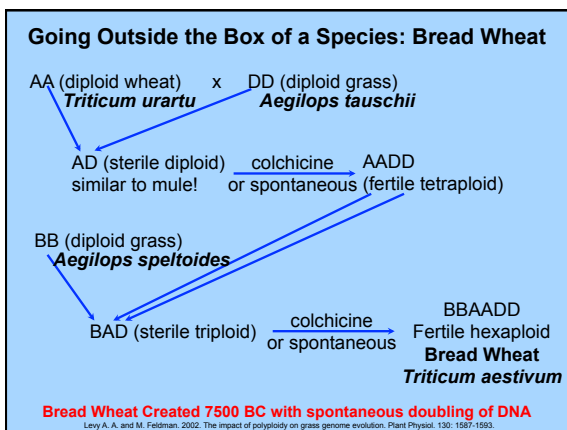
**The sun exposure effect is most obvious in people of intermediate skin base color but everyone can have "tan lines."**

### Who Gets To Mate With Whom? ...Two Extremes

- **Inbreeding Depression:** related parents give same recessives to children  
 Hemophilia: Queen Victoria's Mutation and Diseased Grandchildren  
 Tay-Sachs: Jewish Populations  
 Bipolar: Irish Populations  
 Dog Diseases: German Shepherd hip dysplasia  
**Incest Taboo...but**
- **Hybrid Vigor:** recessives of one family are "covered" by dominant of other family  
 Wild Corn A x Wild Corn B  
 High Yield Hybrid Corn!  
**"Half-breed" is better**  
 Are Human Cultures of "Great Melting Pots" Superior?  
**"Mutt" is best dog!**

### Mechanisms Preventing Inbreeding in Plants

- Evolution of Unisexuality: **Dieocious** Holly and Kiwi  
 Common Gardener Error at Nursery Pickup
- Timing Separation of Bisexuality
  - Protandry: Male First, Then Female (*Alstromeria, Campanula*)
  - Protogyny: Female First (*Oenothera*)
  - Sequence in *Cucumis*: Male, Bisexual, Female, Parthenocarpic
- Self-Incompatibility: Sweet Cherry, Almond, Filbert
  - pollen germination prevented
  - pollen tube growth halted
  - synergid action (sperm release) prevented
  - sperm deactivated



### Yet Another Example of Mendel's Work

**P** Wrinkled x Round  
 ww x WW  
 Homozygous Recessive x Homozygous Dominant

**F1** All Round  
 Ww  
 Heterozygous

F1 x F1 = F2

**Punnett Square:**

		possible gametes		
		W	w	
possible gametes	W	Round WW	Round Ww	3/4 Round 1/4 Wrinkled
	w	Round Ww	Wrinkled ww	

**NEVER use W/R or w/r**

### Mendel as a Scientist

**Test Cross:** Unknown Round x Wrinkled (ww)

**F2 Punnett Square:**

		possible gametes	
		W	w
possible gametes	W	Round WW	Round Ww
	w	Round Ww	Wrinkled ww

**If Unknown is WW:**

		possible gametes	
		w	w
possible gametes	W	Round Ww	Round Ww
	W	Round Ww	Round Ww

Test Progeny All Round

**If Unknown is Ww:**

		possible gametes	
		w	w
possible gametes	W	Round Ww	Round Ww
	w	Wrinkled ww	Wrinkled ww

Test Progeny Half Round Half Wrinkled

### Mendel as a Scientist

Test Cross:	Actual Results	Decision
Unknown Round x Wrinkled (ww)	3 Round 2 Wrinkled	Ww
Unknown Round x Wrinkled (ww)	2 Round 3 Wrinkled	Ww
If Unknown is WW:	1 Round 4 Wrinkled	Ww
	0 Round 5 Wrinkled	Ww
	4 Round 1 Wrinkled	Ww
	5 Round 0 Wrinkled	Ww
	<5% chance unknown is Ww	Ww
	$1/2 \cdot 1/2 \cdot 1/2 \cdot 1/2 \cdot 1/2 = 1/32$	Ww
	You could be wrong (rarely)!	Ww