Lecture 5:

Mendel’s dihybrid experiments

Course 371

Lessons for life

Jim Rohn Official
@OfficialJimRohn

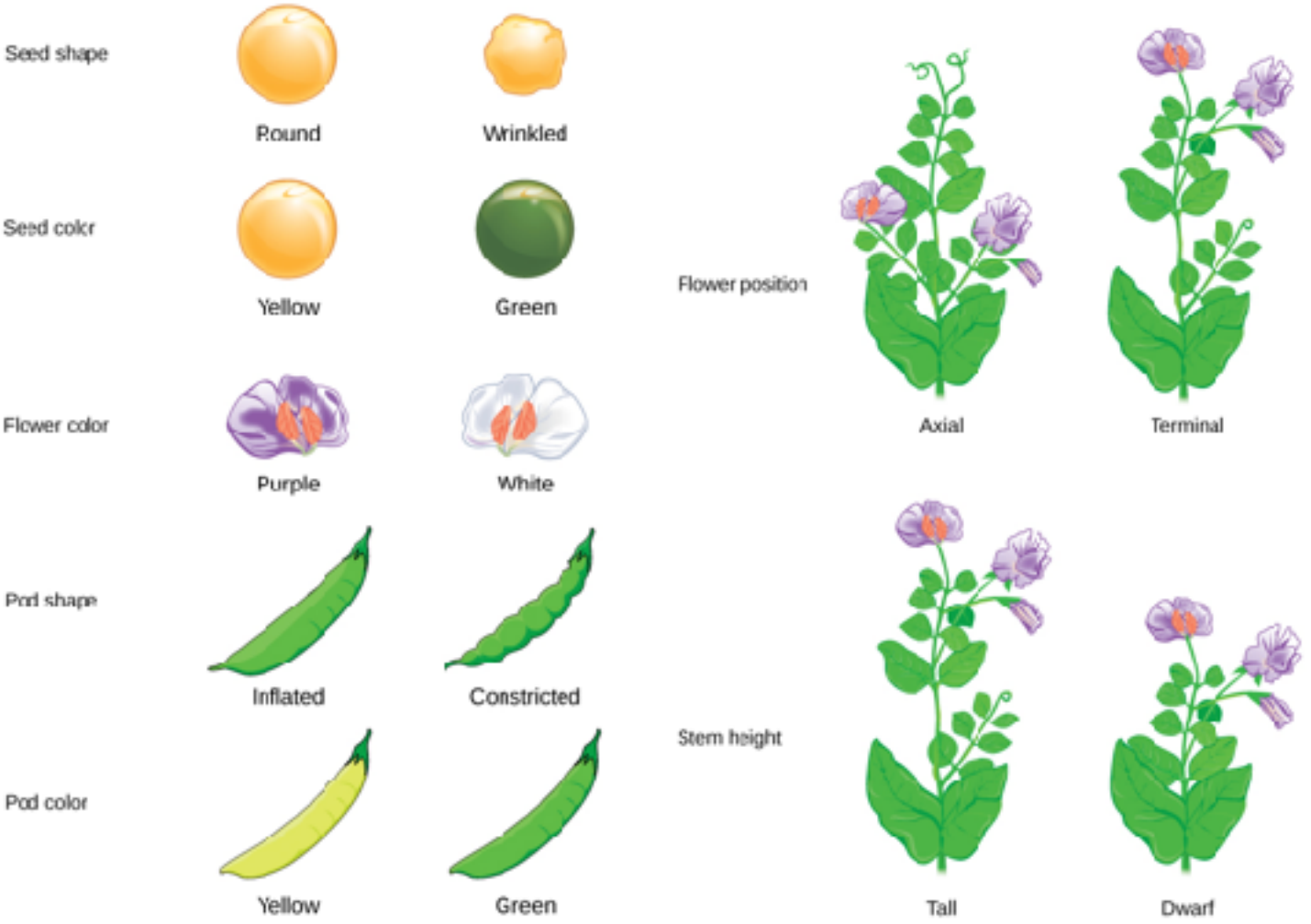
"Don't wish it was easier, wish you were better. Don't wish for less problems, wish for more skills. Don't wish... fb.me/1mMZVacwn

AIMS

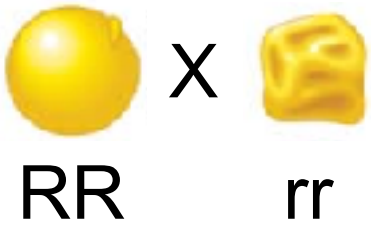
- Introduce Mendel's dihybrid experiment.
- Explain how Mendel's second experiment is a natural extension of his first one.
- Explain the hypotheses tested in the second experiment.
- Present Mendel's results and highlight its significance.
- Explain the reasons for lack of linkage.

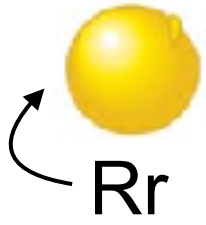
Review Mendel's traits

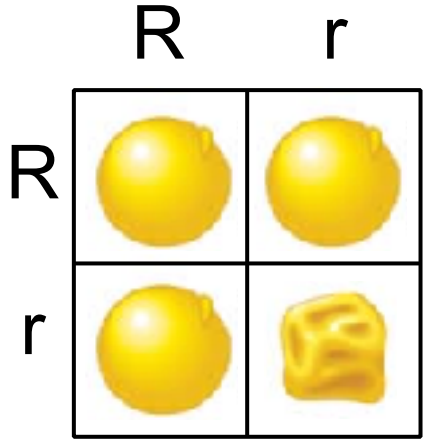
Which traits are the dominant and which are recessive?



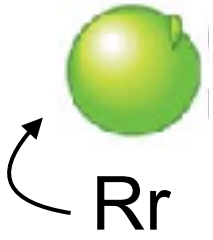
Review Mendel's 1st law

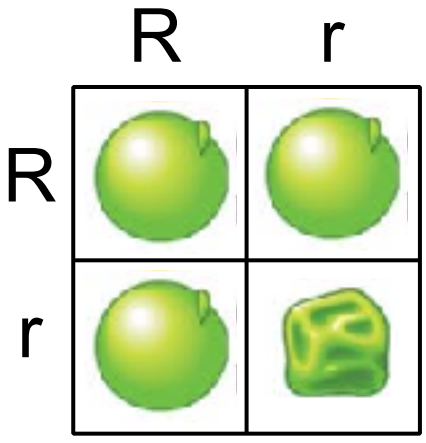






- The focus is only on a single trait (seed shape).
- The factor for shape "round" or "wrinkled" segregates during the formation of gametes.
- Selfing F1 hybrids generates 3:1 ratio of round:wrinkled.



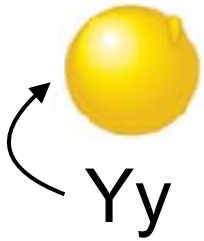


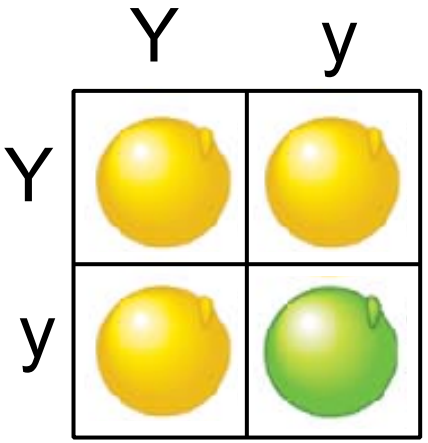
Review Mendel's 1st law

- Why is the notation for "roundness" is "R" and wrinkled is "r"?
- Why don't we use "R" for " round and "W" for wrinkled?

Review Mendel's 1st law

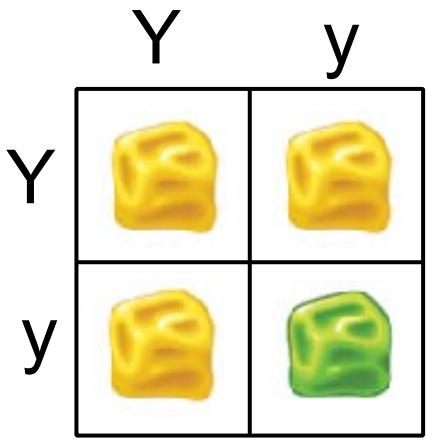
YY yy





Each trait studied individually exhibits the same ratio.

YY yy



Mendel's dihybrid experiment

What happens if we look at two traits together?

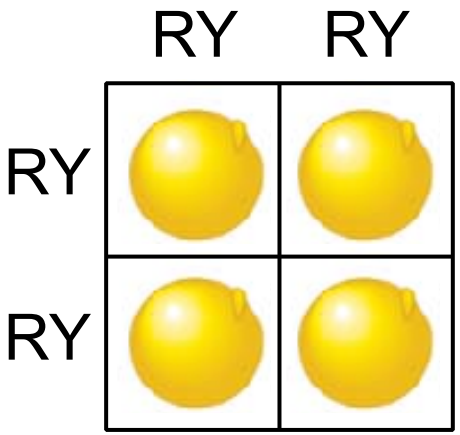
Mendel's dihybrid experiment

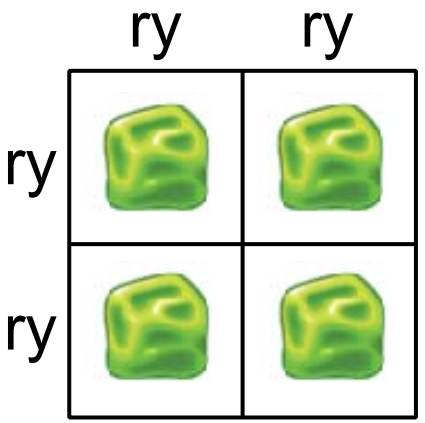
1) Select a pair of traits.

2) Create pure lines (homozygous) for the two traits combined.

3) Yellow and Round homozygous line.

4) Green and Wrinkled homozygous line.





Mendel's dihybrid experiment

5) Cross the pure prenatal lines to generation the first generation dihybrid individual.

What is the genotype of the dihybrid F1?

Mendel's dihybrid experiment

6) Inspect the F2 generation.

7) What are the resulting phenotypes and their ratios?

Hypotheses

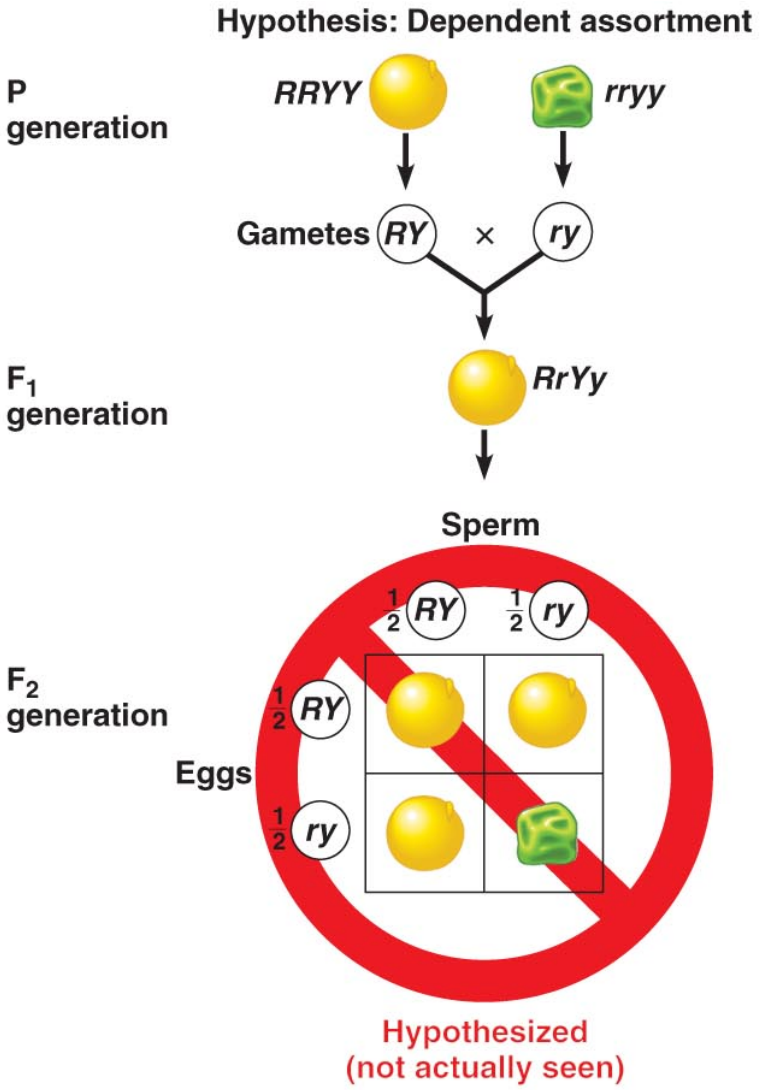
Is the segregation of two factors independent of one another?

Does this result in different combination of the two factors?

H1: dependent assortment
H2: independent assortment

H: Dependent assortment

- The segregation of “R” is always with “Y” resulting gametes of “RY”.
- The segregation of “r” is always with “y” resulting gametes of “ry”.
- The expected ratio of this hypothesis is 3:1.



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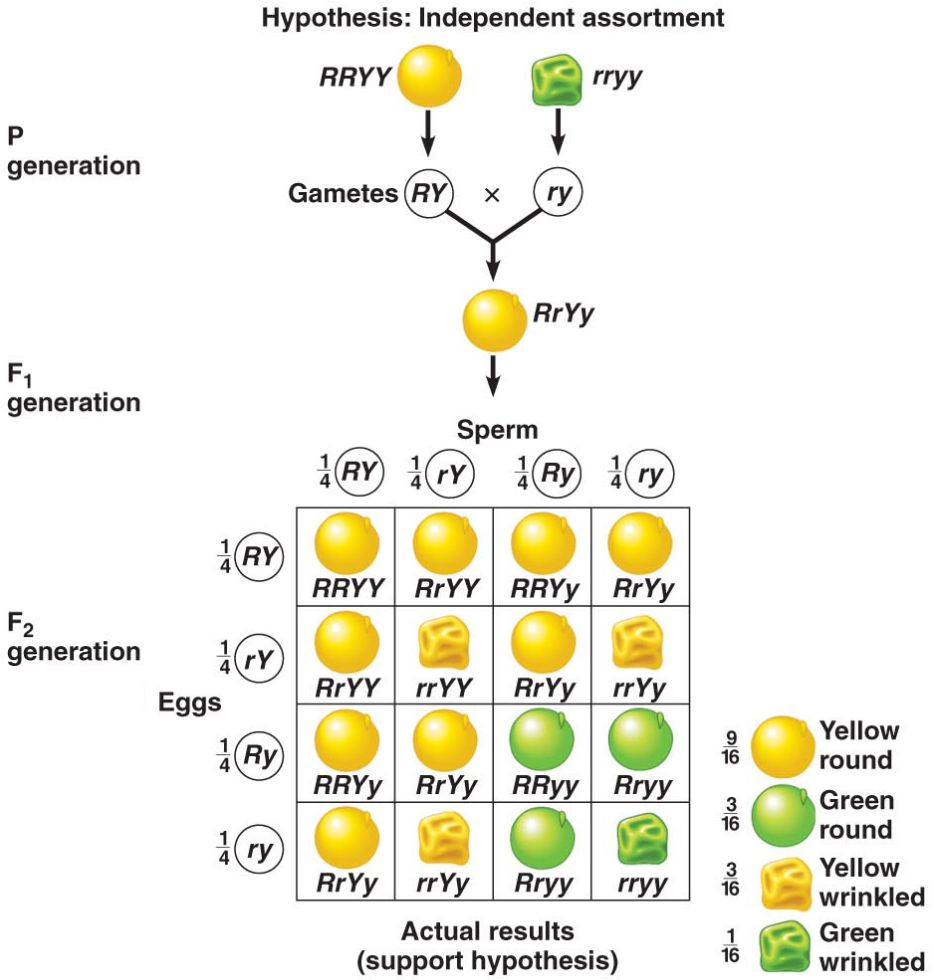
H: Independent assortment

- The segregation of “R” is **independent** of “Y”.
- The segregation of “r” **independent** “y”.
- Gametes of the F1 hybrid carry all combinations of factors (alleles).
- Four phenotypes are a results of the self fertilization.



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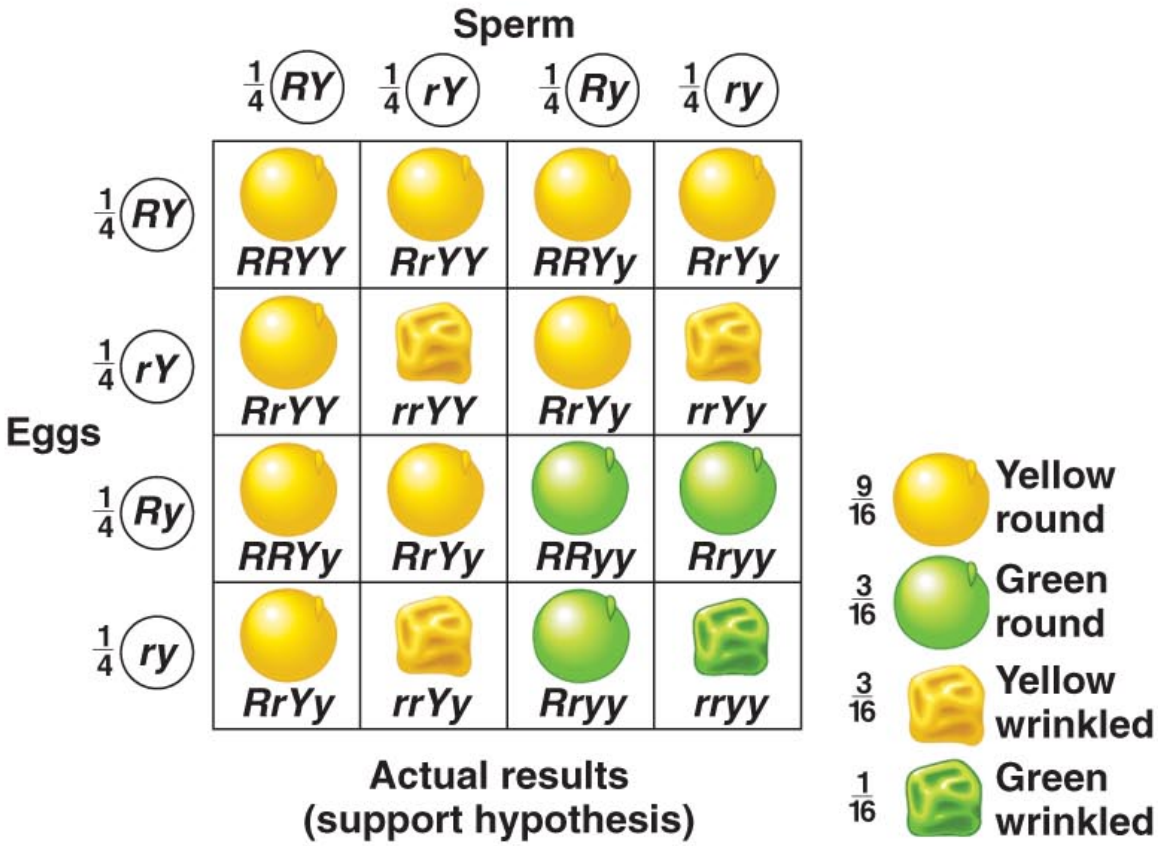
Mendel's Results

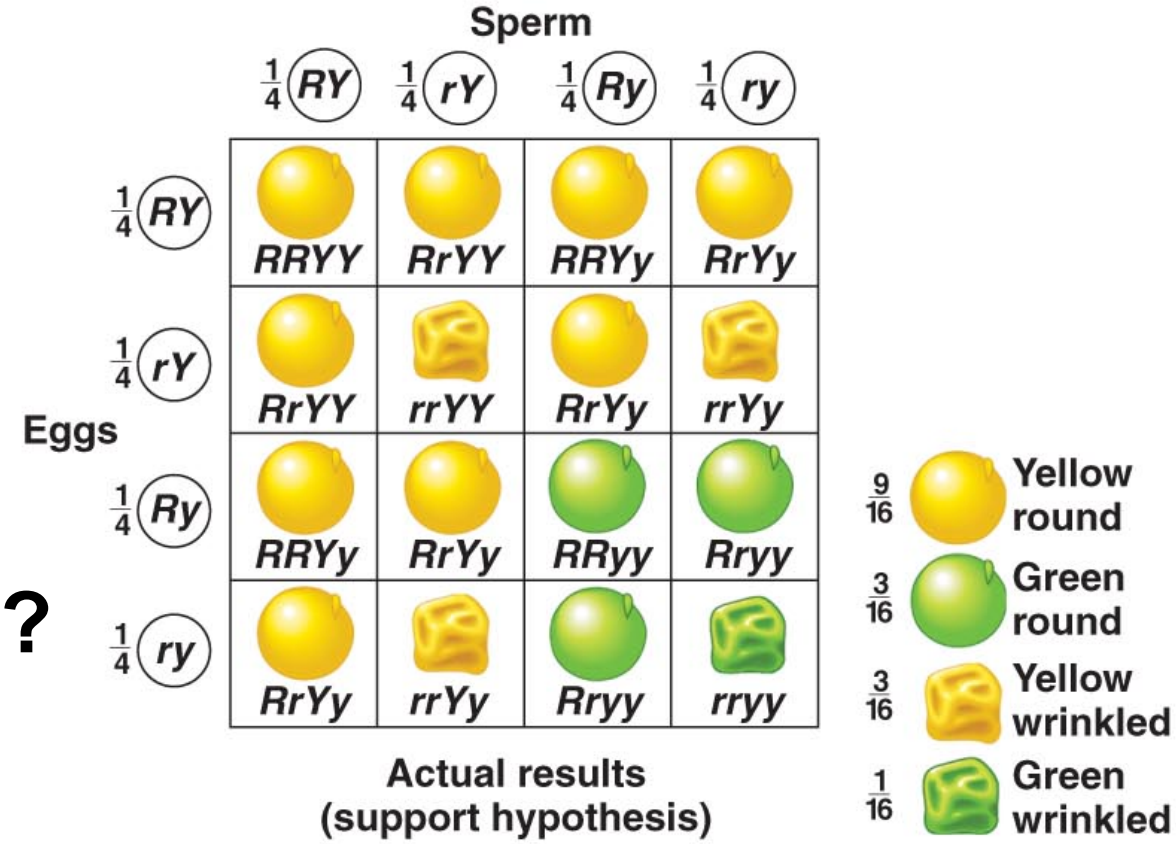
9:3:3:1



- 9 dominant phenotype for both factors.
- 3 dominant phenotype for one factor.
- 3 dominant phenotype for one factor.
- 1 recessive phenotype for both factors

Mendel's Results

What is the ratio of each phenotype independently?



- Yellow : Green = 3:1
- Round : Wrinkled = 3:1

- Each factor segregate independently.

Mendel's Results

Ratios come from numbers (counts)

Parents: **round seeds, yellow seeds X wrinkled seeds, green seeds**

F1: all round and yellow seeds

		Number	Fraction
F2:	round, yellow	315	9/16
	round, green	108	3/16
	wrinkled, yellow	101	3/16
	wirnkled, green	32	1/16

Mendel's Results

How many classes of **Phenotypes** resulted from the dihybrid cross?

How many classes of **Genotypes** resulted from the dihybrid cross?

Pisum sativum Seed Shape & Pod Color

Pheno		Geno
P_1	Round Seed, Green Pod	R R G G
	Wrinkled Seed, Yellow Pod	r r g g
F_1	Round Seed, Green Pod	R r G g
F_2	9 : Round Seed, Green Pod	1 : R R G G
	3 : Round Seed, Yellow Pod	2 : R R G g
	3 : Wrinkled Seed, Green Pod	1 : R R g g
	1 : Wrinkled Seed, Yellow Pod	2 : R r G G
		4 : R r G g
Math "Magic": (more to it)		2 : R r g g
Pheno: $(3:1)^2 = (3:1)(3:1) = 9:3:3:1$		1 : r r G G
Geno: $(1:2:1)^2 = (1:2:1)(1:2:1) = 1:2:1:2:4:2:1:2:1$		2 : r r G g
Thus doubling the hybrid squares the ratio		1 : r r g g

	R G	R g	r G	r g
R G	RR GG	RR Gg	Rr GG	Rr Gg
R g	RR Gg	RR gg	Rr Gg	Rr gg
r G	Rr GG	Rr Gg	rr GG	rr Gg
r g	Rr Gg	Rr gg	rr Gg	rr gg

Dihybrid Punnett Square

Mendel and the factors

R_Y_

rr Y_

R_ yy

How can we test the genotypes of these individuals?

Test cross?
Back cross?

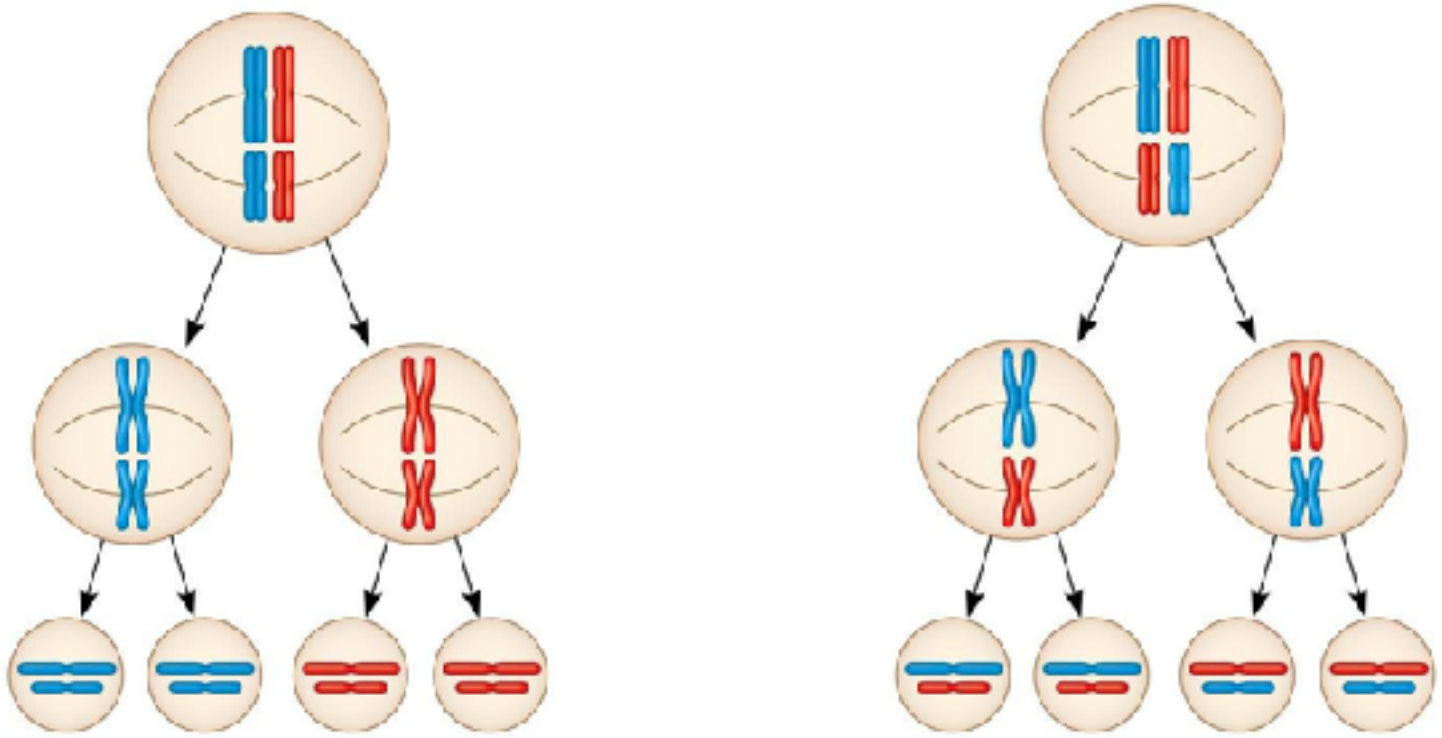
Conclusions

Second experiment conclusions:

- The cross of pure lines give the appearance of one of the parents in the first generation.
- The selfing of the first generation results in the reappearance of different combinations of the parental types.
- A factor/particle are combined randomly as if they were independent entities.
- Multiple factors (now called genes) contribute to the physical qualities of an organism.

Mendel's Second Law

Independent Assortment



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Lucky Mendel

Why didn't Gregor Mendel find linkage?

IT is quite often said that Mendel was very fortunate not to run into the complication of linkage during his experiments. He used seven genes and the pea has only seven chromosomes. Some have said that had he taken just one more, he would have had problems. This, however, is a gross oversimplification. The actual situation, most probably, is shown in Table 1. This shows that Mendel worked with three genes in chromosome 4, two genes in chromosome 1, and one gene in each of chromosome 5 and 7. It seems at first glance that, out of the 21 dihybrid combinations Mendel theoretically could have studied, no less than four (that is, *a–i*, *v–fa*, *v–le*, *fa–le*) ought to have resulted in linkages. As found, however, in hundreds of crosses and shown by the genetic map of the pea[1], *a* and *i* in chromosome 1 are so distantly located on the chromosome that no linkage is normally detected. The same is true for *v* or *le* on the one hand, and *fa* on the other, in chromosome 4. This leaves *v–le*, which ought to have shown linkage.

Mendel, however, seems not to have published this particular combination and thus, presumably, never made the appropriate cross to obtain both genes segregating simultaneously. It is therefore not so astonishing that Mendel did not run into the complication of linkage, although he did not avoid it by choosing one gene from each chromosome.

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Received March 5; accepted June 4, 1975.

[1] Blixt, S., in *Handbook of Genetics*, 2 (edit. by King, R. C.), (Plenum, New York, 1974).

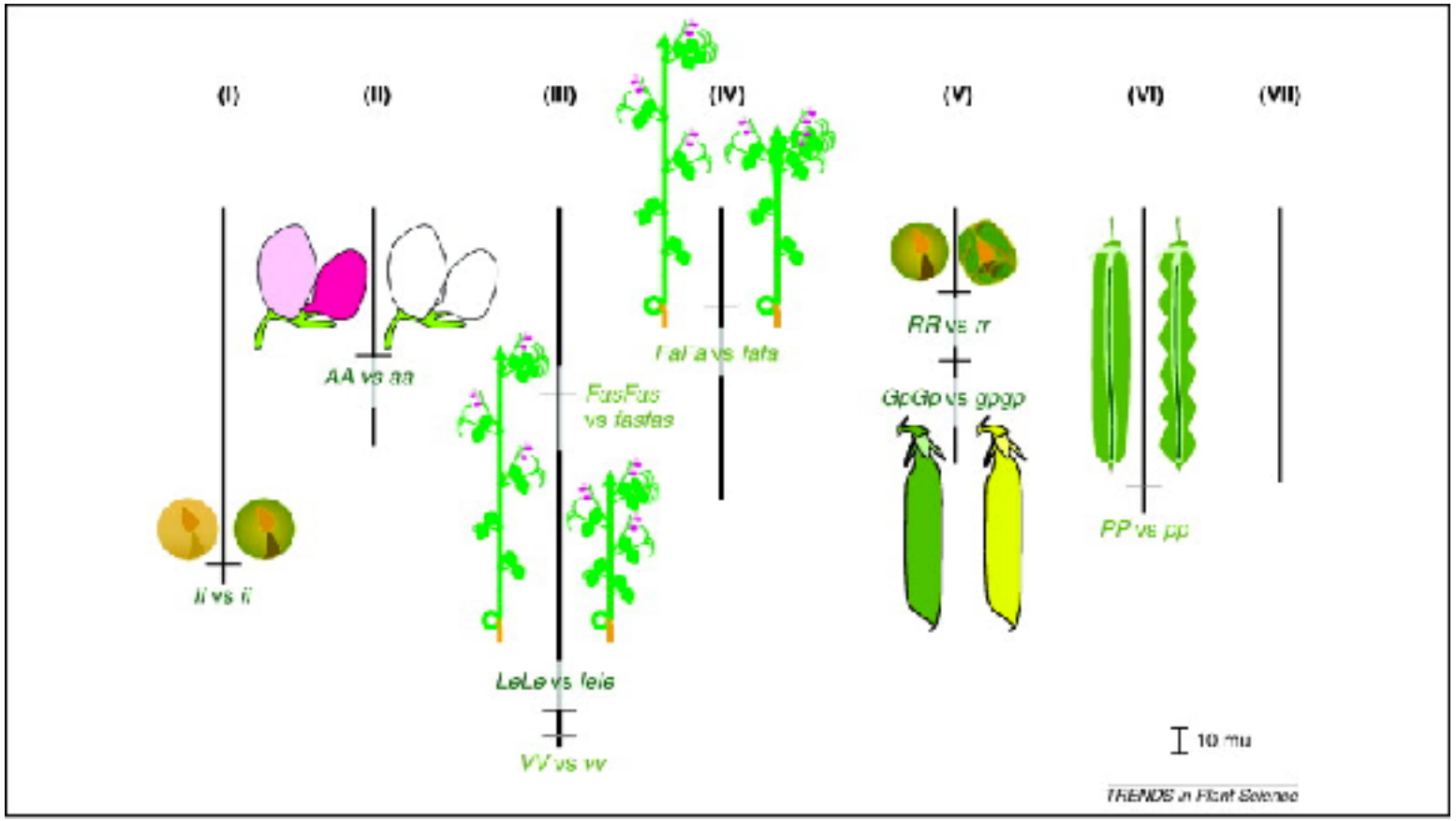
Table 1 Relationship between modern genetic terminology and character pairs used by Mendel

Character pair used by Mendel	Alleles in modern terminology	Located in chromosome
Seed colour, yellow–green	*I–i*	1
Seed coat and flowers, coloured–white	*A–a*	1
Mature pods, smooth expanded–wrinkled indented	*V–v*	4
Inflorescences, from leaf axils–umbellate in top of plant	*Fa–fa*	4
Plant height, >1m–around 0.5 m	*Le–le*	4
Unripe pods, green–yellow	*Gp–gp*	5
Mature seeds, smooth–wrinkled	*R–r*	7

Perfect independent assortment is due chromosomal location of genes responsible for the traits.

Blixt, S. Why didn't Gregor Mendel find linkage? Nature 256, 206 (1975)

Lucky Mendel



The genes of Mendel's traits are located on different chromosomes or far apart on one chromosome.

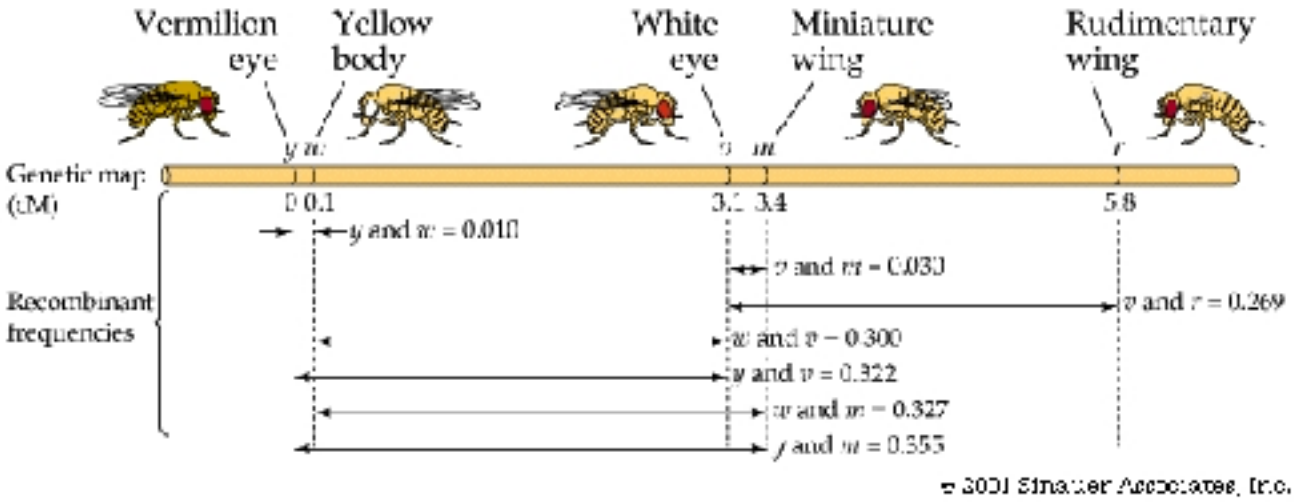
Ellis et. al. Mendel, 150 years on (2011) Trends in Plant Science, 16(11) 590-596

Gene location and maps

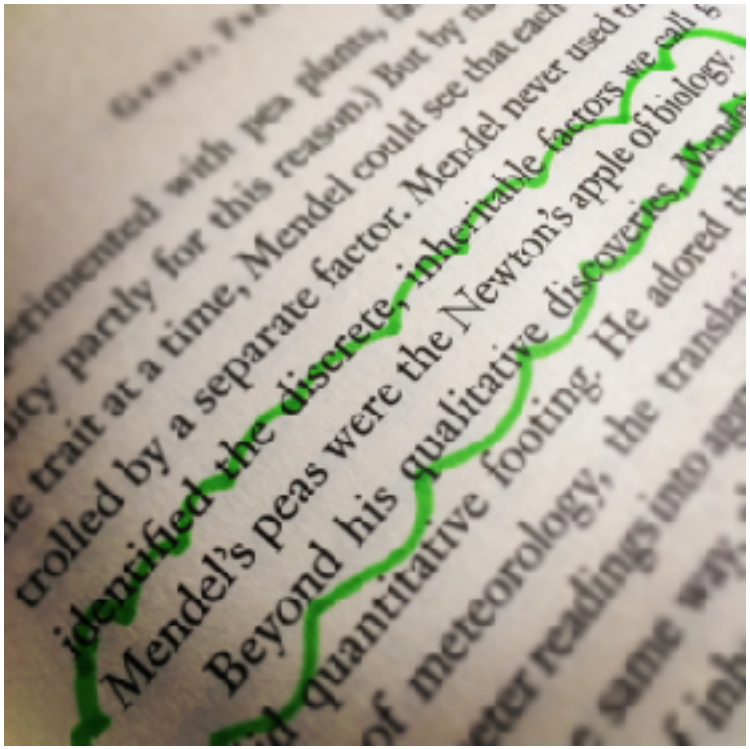
If not independent assortment then what?

1) Genes on the same chromosome and distance between genes can be determined through the numbers of resulting combinations.

2) Genes are located close to one another to be inherited together.



Mendel and the factors



So what?

Where is Mendel's position in the story of molecular biology?

1.Mendel proved that particles reside in the plant give rise to its physical qualities (i.e. flower color).

2.Mendel provided biologist with the law that governs the passing of characteristics from generation to another.

The next questions to ask were

Where these factors (now called genes) are located?

What are they made of?

Expectations

- You understand Mendel's dihybrid experiment and its significance.
- You know the terminology associated.
- You know why Mendel's experiments were essential for the fields (molecular biology and genetics).

For a smile